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Early Elementary Mathematics Lessons to Explore,
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LESSON 5.4 EXAMINING AIR QUALITY

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AIR QUALITY

In November of 2019, schools all over California were learning to deal with a new and dangerous season: smoke season. While California is no stranger to wildfires, the amount and size of the fires that arose in the 2019 fall season, when California is at its driest, created the new phenomenon of air so unhealthy that health experts started issuing guidelines for children to stay inside. “Spare the air” days, which are days where the air quality is so unhealthy that it’s recommended to not engage in strenuous exercise, gave way to “stay inside” days. Most San Francisco Bay Area schools were built for the mild climate that was the norm in the mid-20th century: large outdoor play areas, classrooms that are connected by exterior hallways, and, perhaps most problematic, no central air systems and many older or portable buildings with no air conditioning.

When the first unhealthy air day was announced, children suddenly were inside during recess. Teachers were asked to keep windows and doors closed to limit poor-quality air coming inside, which only led to further issues. Understandably, kids were looking at the window and seeing no rain, and wondering why they needed to stay inside for recess on sunny days. This lesson is designed to help children explore what air quality measurements systems are, and how they relate to whether air is safe to breathe or not. While this lesson does not go extensively into the science of measuring air quality, it could be a springboard into those kinds of questions.

DEEP AND RICH MATHEMATICS

The mathematics in this lesson are meant to support number concepts central to kindergarten. Many children in kindergarten are learning numerals, number names, and rote counting by ones. They are making sense of quantities and how our number system is ordered, exploring ideas like how the more digits a whole number has, the bigger it is. Alongside this, they are reasoning about the meaning of amounts and are learning concepts to compare numbers such as “more than” and “fewer than.”

SOCIAL JUSTICE OUTCOMES

- I see that the way my family and I do things is both the same as and different from how other people do things, and I am interested in both. (Identity 3)
- I know that life is easier for some people and harder for others and the reasons for that are not always fair (Justice 14)

MATHEMATICS DOMAINS AND PRACTICES

- Number and Operations
- Measurement
- Data Collection and Analysis
- Make sense of problems and persevere in solving them. (MP1)
- Construct viable arguments and critique the reasoning of others. (MP3)
- Model with mathematics. (MP4)

CROSS-CURRICULAR CONNECTIONS

- Language Arts
- Science
- Social Studies

More than the particular concepts of number, a central goal of the lesson is to help the children connect numbers to the world outside. The very idea that we can and *do* measure things like particles in the air through some kind of scale is a mathematical goal in this lesson. This lesson is intended to help plant a seed to continue talking about air quality at home, to have some sense of why it's measured, and to show how the number that is measured impacts how we choose to act.

ABOUT THE LESSON

The lesson is introduced in 1 day, but ideas can be revisited in subsequent days. The lesson intentionally has variation in structures for participation: whole group, small group, and then whole group again. Depending on what kinds of resources you have (e.g., a projector), you may need to gather printed-out materials the day prior to the lesson, including large-format images of different regions of the world with varying air quality. You should make the materials easily accessible for all children at their table groups. (Examples of maps are listed in the *Resources and Materials*.)

This lesson can be done in 1 day, over an approximately 45-minute chunk of time. While this lesson highlights specific locations near the school, teachers could modify these locations to include those relevant to the children in their particular context.

Although this lesson was designed for and taught in a kindergarten classroom, it would be appropriate for preschool and primary classrooms. Additional adaptations could be made for other grades, including higher education methods coursework. One suggested extension for older children is included after the lesson flow.

Resources and Materials

For the lesson, you need the following:

- Maps of relevant locations with varying air quality. One good source is PurpleAir (<https://www2.purpleair.com>), especially on days when local areas have poor air quality. Therefore, you may need to plan ahead and collect images of maps from days that are of interest because of the range of air quality. Otherwise, you can search AirNow's archival data and see if you can find relevant map data (<https://www.airnow.gov/>).

- Teacher Resource 1: *Maps for Exploring Air Quality*. This resource provides an example of the different ways two sites show data and the maps described in the lesson.
 - + The images utilized when this lesson was initially designed, and therefore recommended as a starting point, are as follows:
 - Lake Tahoe, California, because many children go there with families in summer and winter, with really good air (green dots);
 - New Delhi, India, which is the city with the distinction of the worst air quality on average (dark purple dots);
 - The entire state of California, which has a variety of dot colors, given the fires; and
 - The school with a two-block radius to include a few sensors, with a variety of dots ranging from green to dark orange.

The following may be helpful too:

- A large image of an air quality table (see Teacher Resource 2: *Three Ways to Display How Air Quality Is Measured*)
- Air quality “number line” meter
- Small stickers for children to predict air quality on the meter
- Teacher Resource 3: *Sample Family Letter on Supporting Children to Keep Exploring Air Quality*

Prior to teaching the lesson, here are suggested resources to develop background knowledge on air quality for yourself.

- Article: “Study finds wildfire smoke more harmful to humans than pollution from cars,” NPR (<https://n.pr/3d6Gr5c>)
- Article: “Long wildfire seasons also mean extended periods of dangerous air quality,” NPR (<https://n.pr/3rqxax0>)
- Radio story: “Smoky air from wildfires impacting parts of California differently,” KQED (<https://bit.ly/3pdt7S6>) [Smoke story starts at 5 minutes]
- Website: California Air Resource Board, “Children’s Environmental Health Protection Program” (<https://bit.ly/3odWpAX>)

LESSON FACILITATION

Launch (5 minutes)

Introduction to the Maps

Call children over to sit on the rug in spots or in rows. Show a map of California (or the state in which the class is located). The goal of the launch is to establish that the class is looking at maps that show them air quality readings.

- Show the map of the whole state of California, and ask children if they know what this is. Give children some time to observe the map and point out what they notice about it. Ask questions to facilitate exploration, and ask children to listen and respond to what other children say. Support them in making connections to the numbers and colors on the map.
 - + Ask questions such as these:
 - + *What does the map show?*
 - + *What colors do you see?*
 - + *What numbers do you see?*
 - + *What do you think different numbers and colors mean?*
 - + *Is this a big number?*
 - + *And it means what?*
 - + *Why are we reading this map?*
 - + *What does it help us see?*
 - + *Could we just go by the color, or does knowing the number help too?*
 - Elicit connections between the map and air quality through a brief discussion about air quality, and why we would measure it.
 - + Ask: *What does air quality tell us? How have we been affected by air quality lately?*
 - Next, have children transition to their seats to explore the maps in small groups.

Explore (approximately 10 minutes)

Children Explore the Maps in Small Groups at Their Tables

Let students know that each table group is going to get a map, and one table group will get the map you have all just been looking at. Directions can be given while children are still in the whole group.

- One group should get the map being viewed in the launch, another group should receive a map from their local neighborhood, one of New Delhi, and other locations as determined by the local school context. Some of

these maps should include locations children are familiar with (in this case, Lake Tahoe).

- At their table groups, children will repeat what they did in the introduction: look at the map, and take turns noticing and wondering.
 - + *I see . . .*
 - + *I know that . . .*
 - + *I wonder if . . .*

Tell them you will circulate and listen to what they are noticing and wondering. It's important to let go here and listen to what children are noticing. That is the priority right now, to privilege students' observations and validate their contributions.

- You can circulate and help make connections to their maps. For example, say: *This is a map of Lake Tahoe. Have any of you been to Lake Tahoe? What do you go there to do? I see green dots with numbers around the lake. What do you think that means?*
- Ask follow-up questions to what students are noticing. Help students read aloud large numbers, if students are not sure how to say them. For example, ask: *What do you think different numbers and colors mean? Is this a big number? What is it counting? I'll read this number for us just in case: three hundred twenty-four. Does that sound like a high or a low number?*
- Prompt students to share different ideas when you return to the rug. It might sound like this: *Can I ask you to share that idea, Simone? You just said, "There's only small numbers like 5 and 6 on our map." Will you share that when we get back to the rug?*

Connect (15 minutes)

Children Make Comparisons Across Maps

Have children come back to the rug, this time in a circle. Put all maps in the middle of the circle, along with an air quality table.

- This time should be carefully structured so children are listening to each other. You might also prompt children to look at and speak to each other, not just you as the teacher. This helps facilitate how the conversation is happening between all of us, not just individual child to teacher.
- Prompt a representative from each group to share a key thing their group noticed, one by one. After each group shares, contrast the two maps with the most extreme measures (in this case, Lake Tahoe and New Delhi; the Lake Tahoe example may change based on the location of context of the lesson).
- Ask children if they think these two places have very different air qualities. For example, ask: *Which place would have been safer to be outside without a special mask for breathing? How do we know?*

From here, support children to make sense of the map of their neighborhood. Hold up the map of the neighborhood around the school and revoice the observations of the group that had this map.

- Facilitate a discussion about how different families are managing with changing air quality. Ask: *Did you go outside yesterday? Did you take precautions?* Students can share their experiences, listen to each other's activities, and notice similarities and differences in how families adjust for changing air quality.

Summarize (5-10 minutes)

Students Take a Position and Support It With Evidence

Tell children that they can use all of this new information to make a decision about whether they can go outside. The teacher holds up the air quality map of the area surrounding the school. In this case, the monitors are giving us different readings, but the principal of the school has to make a decision. The goal of this time is to connect it to the local context. If the decision were up to children, using the information we have, would they declare this an indoor or outdoor recess day?

- Ask children to think, *Do you think the air is mostly good, mostly moderate, or mostly unhealthy? Should we stay inside for recess? Why or why not?*
 - + Children may not use the data presented to draw their conclusions. Be ready to prompt them to think about the color of the dots on the map and the size of the numbers.
- Ask for several volunteers to place stickers on the “air quality number line” where they think today is best represented. Ask them to share why they placed it there and why.
 - + Once a few children have shared ideas, you can close the lesson by reminding them to listen over the next few days for when people are talking about air quality on the news and with their families, and think about the numbers behind the colors.
 - + Alternatively, you can ask pairs of students to discuss and decide. The goal here is not for children to decide whether they are right or wrong, but rather to use ideas of air quality in how they decide. You should be ready to listen carefully and prompt children to make connections back to what the map around our school tells us about air quality.
- Share with children: *When you are outside and smell smoke, or see a lot of gray haze, you can ask the adults in your lives to help you look up the air quality to make decisions about going outside.*

Optional Extension for Older Children (Could Be Completed on Another Day)

You can play the 5-minute KQED radio story on the different impacts of smoke across California (<https://bit.ly/3pdt7S6>; the smoke story starts at 5 minutes). Ask the children to write down any numbers they hear, noting the following:

- + *What number did you hear?*
- + *What did it mean? (for example, I heard 1 month. She said that's the amount of smoke days people experience in a year now.)*
- + *Why would they include that number in the news story?*

This activity is another way to help students connect mathematics to the world around them and to see how numbers and quantities are utilized to communicate information, such as information about the air we breathe.

TAKING ACTION

Suggestions

Individual and Class

The suggested action would be for students to talk about air quality with their parents, to listen at home for when air quality was being talked about on the news, and to have more context for when recess is indoors. The lesson can also serve as part of ongoing conversations about air quality in relation to environmental justice, which could be a thematic unit the children study as some part of the school year.

Local Community, Organizers, and Organizations

Work with local agencies to explore what community/local efforts are happening to study and improve air quality. Share these ideas with school and home communities. Support the school, children, and families in partnering with these agencies.

COMMUNICATING WITH STAKEHOLDERS

Families

Send home a note to parents/caregivers on what the class had talked about and encourage their conversations with their children about the impacts of air quality on our health and why it's important to pay attention to air quality. See the suggested text in the *Resources and Materials* for this lesson.

- Either before or after the lesson, you can reach out to classroom parents and request that they ask their children what they did with air quality maps at school that day. Parents can ask children what they noticed on the maps, what other people said, and then if they have any questions. In this way, parents are supporting the students to notice, wonder, and ask and answer questions. They are cultivating their students' curiosity as well as supporting key mathematics and science practices about asking questions and engaging in problem solving. An example letter is provided in the online resources (Teacher Resource 3).

Other School/District Personnel

- Create posters to put around the school about why recess is sometimes indoors. Younger children might pair with older children to make them.
- Create an air quality monitor and incorporate it into daily calendar routine for a month or so following the lesson. Teachers can make a bar graph and retrieve the measurement from nearby monitors on PurpleAir (<https://www2.purpleair.com>), either on a laptop or their phones, and children could fill in the bar graph for the right range. It may be sufficient for the teacher to include just the first four categories and make the fourth one a catch-all for any reading over 151. It should also be anticipated that we have all good or mostly good days, with some moderate days, which would still have mathematical value.

BACKGROUND OF THE LESSON

As residents of California will tell you, we have had “spare the air” days as long as we can remember—days when the state’s air quality board would send out announcements to our radio stations to tell people not to exercise too strenuously or burn unnecessary fires if they weren’t needed for heat or cooking. Spare the air days are a result of taking a scientific approach to the smog and smoke that are part of living in our state. However, even as clean-air vehicle initiatives have been successful and industrial pollution has declined in California, we have seen a rise in wildfires. This rise has led to an increase in poor air quality days, and fears for children’s health should they breathe the cancerous particulates released during wildfires, especially fires that burn toxic materials used in housing. This is also to say nothing of the families who lose their homes to wildfires, and the trauma left in the wake. In my community in Oakland, California, a community that remembers a devastating fire in the Oakland hills in 1991, children are growing up with multiple days out of the year in which they are kept inside or kept home from school due to poor air quality. This is exacerbated by the COVID-19 pandemic, as protocols require children to eat lunch outside because there is less possibility of COVID transmission, but there is still the possibility of poor air quality.

When this lesson was developed, it was prior to the start of COVID, but not much. My son was a kindergartener and I was volunteering in his class. There were 2 days in a row that children were not allowed outside for recess, and it was frustrating for both the adults and kids. I asked the teacher if I might do a lesson on air quality to help children understand that even if they couldn’t *see* why they couldn’t go outside, there was a reason. The air quality lesson was developed as a result of me virtually spanning the globe through the PurpleAir.com map and looking for places where we could contrast the air quality. With the visual anchors of the maps, the rest of the lesson fell into place.

When I did this lesson with the kindergarteners, it was November of the school year. The lesson was launched in a whole-group setting with noticing and wondering about the map of California. After a few minutes of sharing what they noticed and wondered and establishing that this was a map of the state of California and that it had different-colored dots, the children were dismissed to their table groups to pore over one of the maps and prepare to report back on what they saw on their map. What color dots were there? What numbers? What do they think the dots and numbers mean? Most students thought the numbers were street addresses.

After a few minutes in small groups, they returned to the rug. A representative from each group shared their noticing. The table for air quality and concept of air quality was explicitly introduced at that point. We focused on the contrast between the Lake Tahoe map (great air quality, low number also indicated by green) and our school map (not great air quality, in the low hundreds, indicating harmful for sensitive groups). We spent the last few minutes trying to decide if the map of our area meant we should or should not go out for recess. Finally, students were reminded to talk with their parents about air quality, listen to the news for when air quality was talked about, and know that there are numbers behind how we decide that air is good or bad to breathe.

ABOUT THE AUTHOR



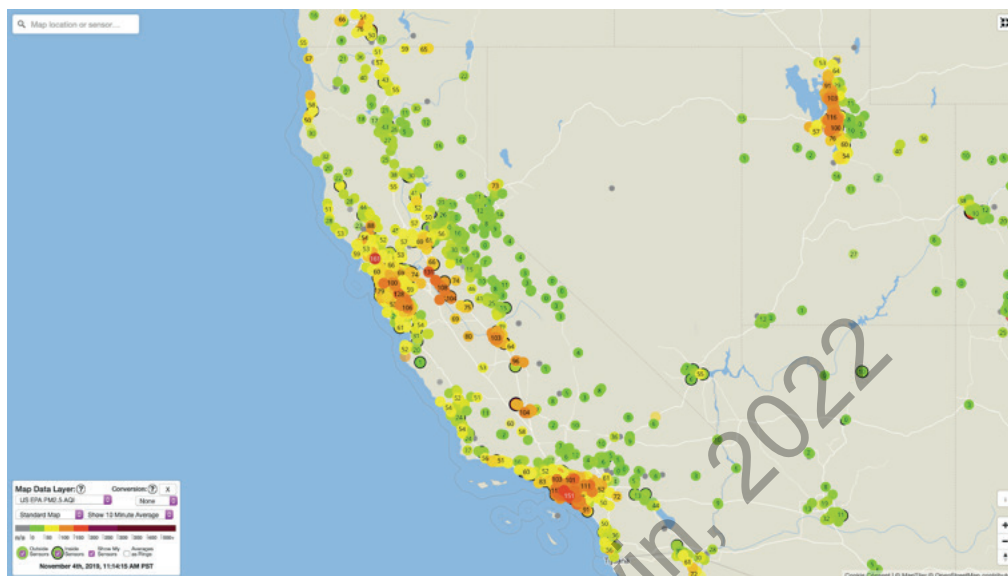
Maria del Rosario Zavala, PhD, is an associate professor of elementary education at San Francisco State University, with a focus on culturally responsive mathematics teaching, mathematics identity development, and bilingual education. She had various roles in education spanning K–12 schooling prior to her role at SFSU, and she continues to work in classrooms whenever she has the chance. In terms of social justice, she gives credit to her college professor at the University of California, Santa Cruz, Dr. Julia Aguirre, whose class she took as an undergraduate mathematics major. This course helped her to call out and start to really wonder about inequities in mathematics education and to make sense of her own experiences as a bilingual Latina woman. She views the teaching of mathematics as open to creativity, with limitless opportunity to connect to issues that impact children’s communities and lives.

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Maps for Exploring Air Quality

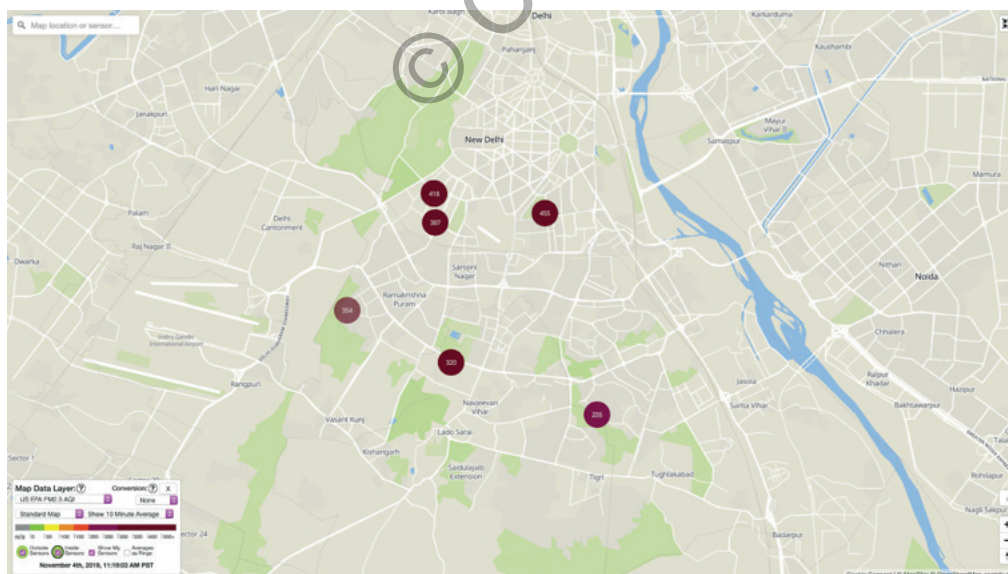
You are encouraged to use the rationale behind the selection of these specific maps to find and copy your own for your classroom, or try out the activity with the particular maps provided and more geographical background information.

1. First map showed the whole state of California, to both orient us to place and space and illustrate the variation in dot colors.



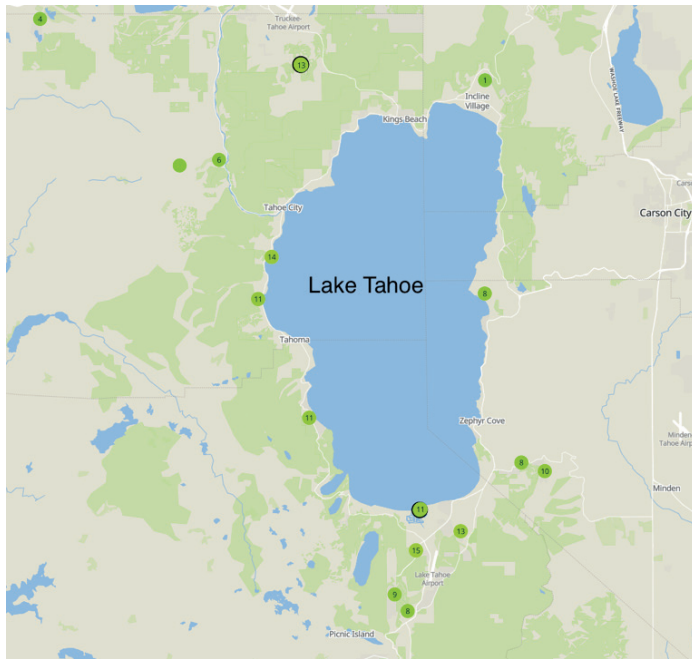
Source: PurpleAir, www.purpleair.com

2. Second map showed New Delhi, India, a city with notoriously poor air quality, as a contrast to the other maps.



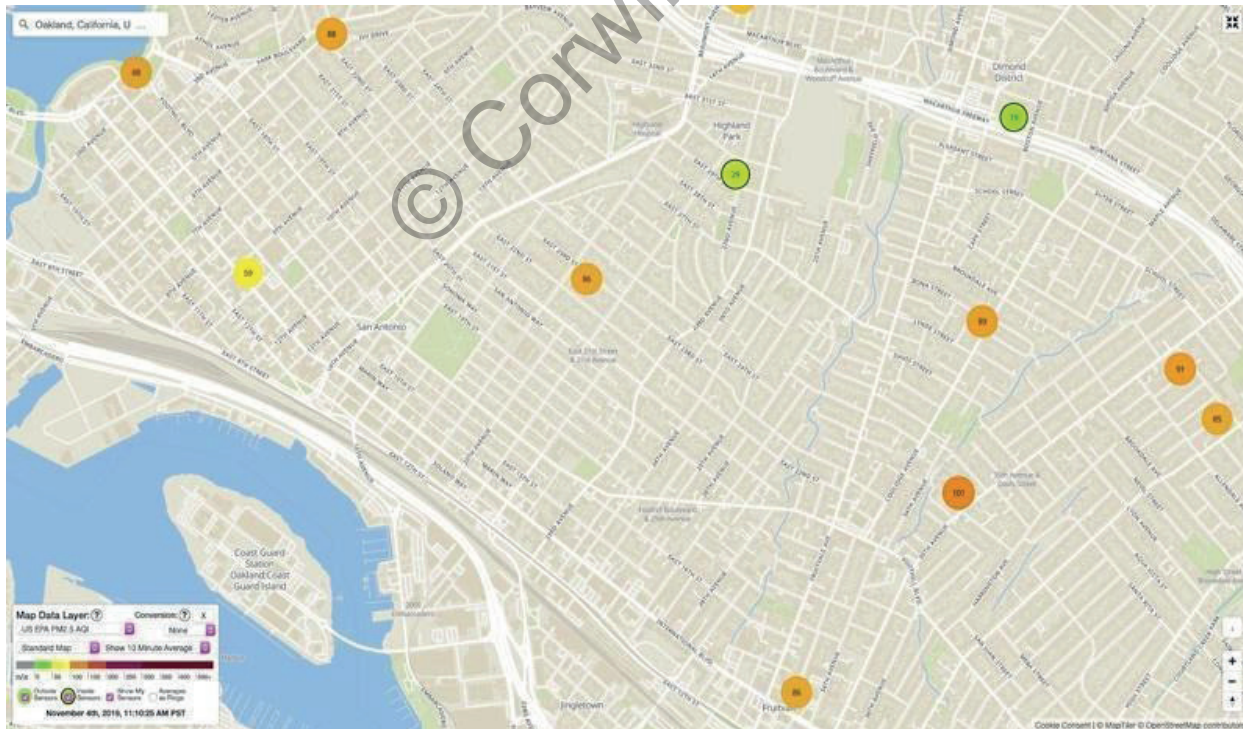
Source: PurpleAir, www.purpleair.com

3. The third map was to contrast our location (with very poor air quality) with a location that had very good air quality on the same day, and was familiar to many children from the SF Bay—the region around Lake Tahoe.



Source: PurpleAir, www.purpleair.com

4. Finally, the last map was of the region around the school.



Source: PurpleAir, www.purpleair.com

Three Ways to Display How Air Quality Is Measured

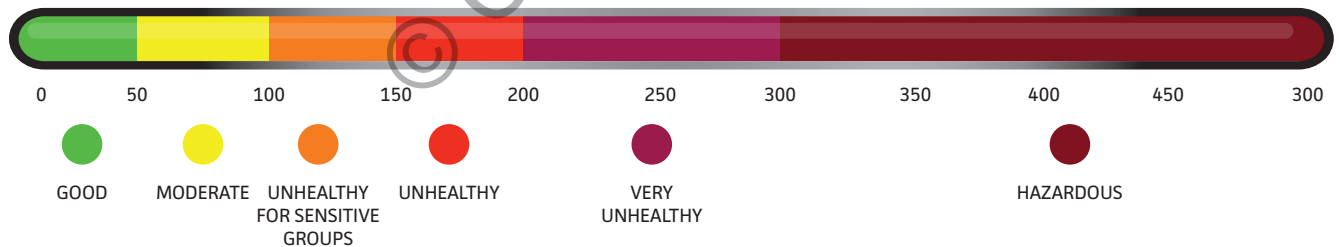
You are encouraged to consider what different representations serve the purposes of your lesson. For example, the one that looks more like a number line may be useful for building a bar graph, while others might emphasize a color associated with a number and more in-depth descriptions.

1. Table model— Can be useful to orient students to ideas of air quality, and serve as a reference for interpreting AQI index values.

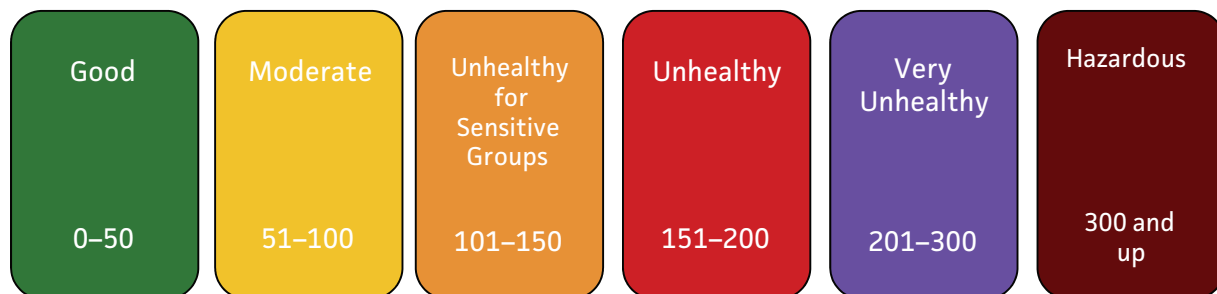
Daily AQI Color	What are the AQI index values?	What does it mean?
Green	0 to 50	Good: Air quality is satisfactory, and air pollution poses little or no risk
Yellow	51 to 100	Moderate: Air quality is acceptable, but there may be a risk for some people, particularly those who are sensitive to air pollution.
Orange	101 to 150	Unhealthy for sensitive groups: Members of sensitive groups may experience adverse health effects. The general public is less likely to be affected.
Red	151 to 200	Unhealthy: Some members of the general public may experience health effects. Members of sensitive groups may experience more severe health effects.
Purple	201 to 300	Very Unhealthy: The risk of adverse health effects is increased for everyone.
Maroon	301 and higher	Hazardous: Health warning of emergency conditions, where everyone is more likely to be affected.

Adapted from: <https://www.airnow.gov/aqi/aqi-basics/>

2. Numberline model— preserves scale. Can be useful to build a bar graph based on the measure of air quality.



3. Bar model— representing the categories, does not preserve scale. Can be useful for displaying the range, or when sorting by category is the priority.



Sample Family Letter on Supporting Children to Keep Exploring Air Quality

The following text can be used to create a letter home to families after the air quality exploration.

Dear Families:

Today in math class we looked at air quality sensor maps and talked about how different color dots have different numbers that mean the air is safe or unsafe to breathe. Please follow up with your child by asking what they did in class today with the air quality maps. Take the time to listen to the questions your child has, and encourage them to keep noticing and wondering about the world. Do not worry if you cannot answer their questions, since for right now it's less important that you answer all their questions and more important that you encourage their curiosity. You might ask:

- What were those maps you were looking at in class today?
- What did the different dots on the map mean?
- What did you notice about the maps?
- Do you have any questions now about air quality?

Encouraging your child to ask questions about the world, and the ways that numbers represent actual *things* in the world, is a key part of their mathematics and scientific thinking development. The first science practice standard is “Ask Questions,” and the first mathematics practice standard is “Make sense of problems and persevere in solving them.” By engaging children with their questions, curiosities, and ideas of how the world works, including how numbers in the world work, you are developing these important foundations for further mathematics and science learning.

Keep it up!

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