BIG IDEA 1

Solving Problems with Data

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We begin this grade 3 book with a topic that is extremely important to the 21st century but that is often left out because of time constraints. Textbook publishers often place measurement and data at the end of books, but we have chosen to open with this topic to acknowledge its importance. The activities in this big idea give students opportunities to explore and understand their world—inviting them to ask their own questions and discuss the relevance of data. There can be few more critical activities in which students engage as they learn to be mathematically literate citizens.

In the Visualize activity, we invite students to wonder about the lengths of animal tongues, which should be interesting and engaging. Students are also asked to read a bar graph and work to interpret what it is telling them. We have chosen some animals we think students may be curious about. We encourage you to allow students time to investigate and find out more about the animals. As students work to make sense of graphs and data, they will develop quantitative literacy, which is an extremely important attribute. As students read the graph and work to understand what it is telling them, they will need to pay careful attention to the way the vertical axis is numbered. Later in the activity, we provide students with tables of data and ask them to create visual images that communicate the data. This lesson is inspired by a book by Steve Jenkins, *Animals by the Numbers.* Having this book available for students would be a nice addition to the lesson.

The Play activity provides students an opportunity to use what they learned in the previous lesson as they inspect a graph that has some mistakes. One of the most debilitating ideas for learners is the myth that they always have to be right.

Our Youcubed team has worked hard to dispel this myth by communicating the neuroscience which shows that when students are struggling and making mistakes, brain growth occurs. This lesson is a good time to celebrate the value of mistakes and communicate the brain science information that we also share here: https://www.youcubed
.org/resource/brain-science/. Students in this lesson are again encouraged to develop quantitative literacy by reading graphs that display data, and noticing and discussing the mistakes in the graph. It is important to embrace the mistakes and talk about mistakes in playful rather than pejorative tones. Students then get the opportunity to make their own mischievous graph where they can try to mislead their peers with a display that contains mistakes. We think students will love playing Inspector Graph-It.

In the Investigate activity, students investigate a real question about the most common car color in their area. They will pose the question and determine together a data collection plan. Later they will take the data and interpret it to answer the question about car color. This provides an opportunity for students to think about a real question and also consider together why this could be useful information. The extension in this activity is worth the extra days. Students have an opportunity to ask their own questions and collect data. An important goal for us as mathematics educators is to give students opportunities to act with agency—to use their own thoughts and ideas as they work mathematically. It is very helpful to give students opportunities to ask their own questions—instead of only answering questions that have been given to them. When students ask their own questions of data, we achieve both of these goals.

Jo Boaler

Tongues, Tails, and in Between

Snapshot

Students investigate a graph of the lengths of different animals' tongues to develop ways of interpreting data displays, with a focus on reading a scaled axis. Then students choose a set of animal measurement data and create their own data displays to compare and discuss.

Connection to CCSS
3.MD.3
3.NBT.2, 3.NF.1, 3.OA.3

Agenda

Activity	Time	Description/Prompt	Materials
Launch	5–10 min	Show students the Animal Tongue Lengths graph on a projector and ask what the graph shows. Collect students' observations and the reasoning behind them.	Animal Tongue Lengths graph, to display
Explore	20–25 min	Partners record their observations of the data in the Animal Tongue Lengths graph. Using these interpretations, partners may construct alternative data displays.	• Copies of the Animal Tongue Lengths graph, one per partnership • Optional: 1" grid paper (see appendix)
Discuss	10–15 min	Discuss the observations students made of the Animal Tongue Lengths graph and how they read the measurements on the scaled vertical axis. Discuss students' alternative data displays, for those who made them, and compare the ways the data is shown.	Animal Tongue Lengths graph, to display

(*Continued*)

Activity	Time	Description/Prompt	Materials
Explore	20–30 min	Partners choose one of four Animal Data Tables and make observations about the data. Partners then create a data display that communicates what they think is most interesting in the data.	• Animal Data Tables, copied and cut into quarters to provide choices for partners • Make available: 1" grid paper (see appendix), colors
Discuss	15+ min	Students do a gallery walk of the data displays others have created and leave sticky notes with observations and questions. The class discusses what different displays communicate and what makes a data display interesting.	Small sticky notes

To the Teacher

In this lesson, which can extend across two days, students begin to think about how data can be visual, and the relationship between data and displays. As adults we often have a great deal of comfort with the kinds of data displays used in third grade, and understanding these images comes quickly. But for children, these images don't immediately make data obvious; it takes experience interpreting data displays to become fluent in this visual form of reading. This lesson is designed to give students the opportunity to read displays without the need to answer particular questions imposed from the outside. Instead, we hope to inspire wonder. The bar graph we've constructed to launch this lesson, based on the beautiful data in Steve Jenkins's book *Animals by the Numbers,* is intended to be intriguing and to get students wondering about the data and the unusual animals it represents. If students want to find pictures of these animals or investigate in other ways, we encourage you to support their curiosity. If you have access to *Animals by the Numbers,* we encourage you to make this book available to students to explore the many creative ways Jenkins displays and communicates data.

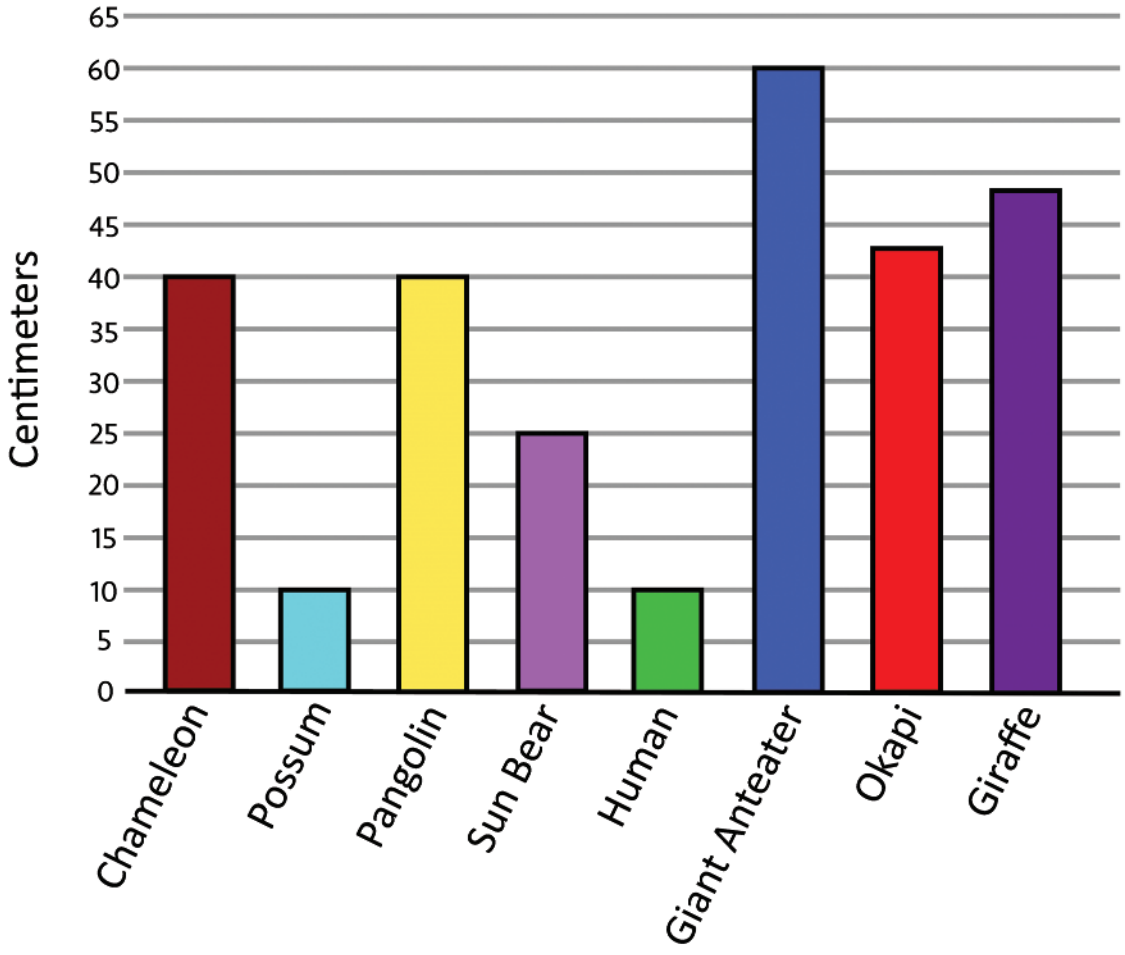
The graph poses a mathematical challenge important for students to grapple with. The vertical axis is scaled in increments of 5, rather than one, and not all of the data falls neatly into multiples of 5. Students need to attend to these increments to measure the length of a bar, and they will need to think proportionately to estimate

how long a tongue might be that falls between two increments. Encourage students to make their thinking about these estimates public and discuss which inferences are reasonable and which are not convincing. Several mathematical concepts intersect when students are doing this work, and it is useful to bear in mind all that students are working to integrate. Students need to think in terms of equal groups and skip counting to interpret (and construct) the scaled axis; they need to be thinking about differences on a scale to interpret comparisons; they need to interpret the axis as a number line and think fractionally about the values between increments. Any one of these concepts could provide productive struggle for students as they work first to interpret and then to construct graphs.

Activity

Launch

Launch this lesson by showing students the Animal Tongue Lengths graph on a projector. Ask students what they notice in the graph, or, What does this image show? Give students a few moments to turn and talk to a partner about the graph. Collect from students a few of their observations about the graph. Encourage students to come up to the graph to point out the specific features or data points they notice. Press students to explain any inferences they have made. For instance, students might infer that one animal's tongue is longer than another. You'll want to ask students to point out the specific feature of the graph that communicates that idea. Students might connect a bar with an animal's name or with a measure on the vertical axis. Be sure to probe how they made this connection. Use this brief discussion to encourage students to notice details and make their reasoning public before sending them off to make observations with a partner. Tell students that today they will be exploring this graph and trying to figure out all it is telling us.



Animal Tongue Lengths

Explore

Students work in partners to make observations about the Animal Tongue Lengths graph. Provide each partnership with a copy of the graph. Students record their observations directly on the graph as annotations. Students can use words, numbers, arrows, or other ways to indicate what they are noticing about what the graph communicates. Encourage students also to pose their own questions of the graph and record these as well.

If students collect many observations about the data, you might challenge them to come up with another way to show this same information. They might create a table, list, or another graph. Encourage students to experiment with ways to show the data. Students' attempts will likely be incomplete or unconventional, but this

activity will engage students in trying to capture data in different ways. Make grid paper available (see appendix) for those who'd like.

Discuss

Gather students together and ask them to contribute their observations of the graph. Annotate a shared class graph on the projector with what students noticed.

- Ask, What do you notice? How did the graph communicate that information?
- If students notice comparisons, such as one animal's tongue is longer than another's, ask, How much longer? How do we know? Note that these differences may be estimates, and their reasoning should convince the class, even if multiple estimates are reasonable.

Be sure to draw attention to how to read the measurements when students are making claims about the data shown. Ask students how they read the scale on the side for any measurements they interpret.

If students made alternative data displays, invite them to share what they created and how they thought about communicating the data. Ask the class to make connections between different displays. For instance, you might point out a particular data point and ask the class how the different displays show that information. Ask the class how the different displays help them see the data, or how different displays make it harder to see the data.

Explore

Provide students with the choice of four data tables: Tail Length, Tooth Length, Brain Weight, and Horn Length. Show the data tables on the screen to introduce students to their choices. Invite partners to choose a data set to work with. Provide copies of 1" grid paper (see appendix) and colors.

Partners first need to look at the data and decide what's interesting. Ask student to explore, What does the data show? Then partners create a graph to show the data in their chosen set. Encourage students to organize the data to help others notice what's interesting about their data. They might choose to display all or only part of the data in the table. Students may choose to construct a bar graph similar to the Animal Tongue Lengths graph, or a different data display, such as a pictograph. The

key is that students are selecting ways to show what they want others to notice about their data. Be sure students give their data display a title and other labels to help the reader interpret the data shown.

For an optional extension, you may want to invite students to add new data to their tables and displays. If you have resources in your classroom, on the Internet, or in the school library, students could add another animal or two to their data that they think offers an interesting comparison with the existing data.

Discuss

Ask partners to post their data displays around the classroom, either by putting them on the walls or by laying them out on their tables. Do a gallery walk, in which partners walk around looking at the different graphs created. As students look, ask them to consider the following questions:

- What do you learn from the graph?
- What questions does it raise?

Provide students with small sticky notes on which to record their observations and questions. After students have had the chance to look at the different displays, gather the class to discuss the following questions:

- What did you learn from the different graphs? How did the graphs help you learn that?
- What made the different graphs interesting, helpful, or informative?
- What did you notice looking at different graphs of the same data? How did people organize the data differently to show different things?

Invite partners to look at the sticky notes people left for them. Ask partners to discuss with one another, What did others learn or ask? What would you do differently next time? As a whole class, discuss the following reflection questions:

- Did others notice what you hoped they would in your data?
- What did others notice in your data that surprised you?
- What would you revise in your data display to make it more interesting or to better show the data? Why?

Look-Fors

- **How are students interpreting the scale of the graph?** Be sure to support students in attending to the numerical labels on the vertical axis and noticing that they count by 5s. Students may struggle with understanding the meaning of the space between two multiples of 5. It may help students to first focus on an animal with a tongue length that is a multiple of 5, and ask them how long the tongue is. Ask students what the horizontal lines are for or how they help us. Ask, What does it mean when a bar is a little above or a little below a line? What does it mean when a bar is right between two lines?
- **Are students being precise about comparisons?** Students may make qualitative comparisons between tongue lengths, simply saying that one is longer or shorter, or way longer or much shorter, than another. Encourage students to name precisely how much longer or shorter using the graph. To make precise comparisons, students will need either to interpret the two lengths and subtract them or to focus on the vertical distance between the two bars and reason about that difference. To help students think about differences, you might draw students' attention to two similar data points, such as the human and the possum, and ask students to reason about their difference and how the graph shows the difference.
- **Do the graphs students construct match the data tables?** Students may invent many different ways to display the data they have chosen, but whatever creative ideas they try, the display should match the data. As you look at the displays students are constructing, ask them questions about the decisions they have made, such as, How did you decide to display the data this way? What are you hoping others will notice in your data? How does the data in your display match the data in the table? How did you decide on how to label your measurements? Pay attention to the relationship between the data points: Are large values large on the graph? Are small values small? And pay attention to the precise measurements to see if the values are exact.
- **How are students placing data on a graph when estimation is required?** If students have chosen to mark their vertical axis by 5s or an increment other than 1, how are they placing data that falls between these increments? Ask students questions about their reasoning to help them connect quantity to distance. For instance, on a graph with increments of 5, students should be

thinking of placing 6 cm just above a line and 9 cm just below a line, whereas 7 cm and 8 cm would be in the middle.

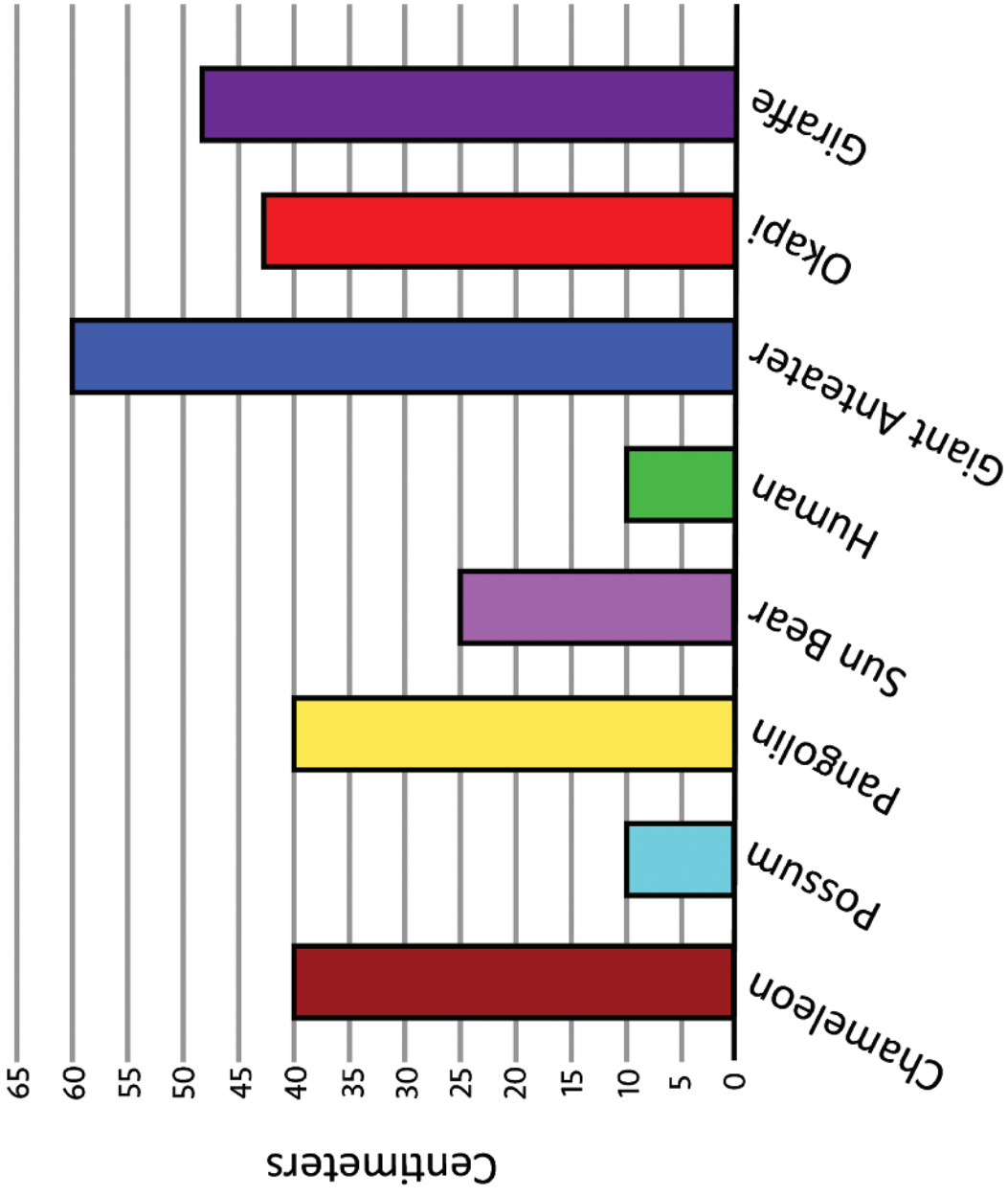
Reflect

What features make a data display useful to the reader?

Reference

Jenkins, S. (2016). *Animals by the numbers: A book of animal infographics.* New York, NY: Houghton Mifflin Harcourt.

Animal Tongue Lengths



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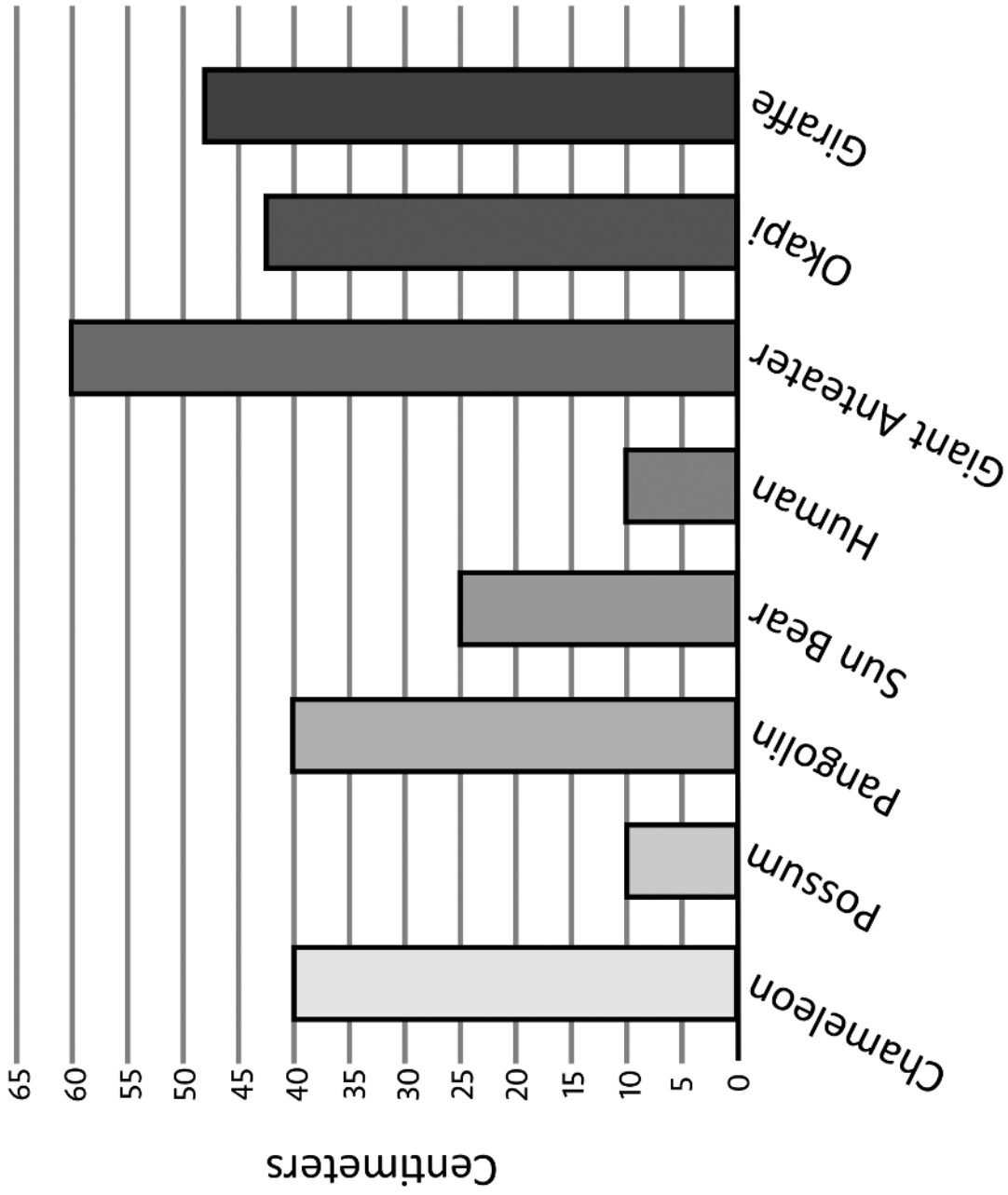
Animal Tongue Lengths



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Animal Data Tables

Animal Tooth Lengths (Centimeters)

Animal	Tooth Length (cm)
Tiger	8
Hippopatamus	40
Narwhal	180
Lion	10
Gorilla	2
Musk Deer	7
Great White Shark	7
Baboon	5

Animal Tail Lengths (Centimeters)

Animal	Tail Length (cm)
Kangaroo	100
Lemur	60
Giraffe	100
Tiger	110
Alligator	200
Opossum	30
Lion	80
Red Tailed Phascogale	15

Animal Brain Weight (Grams)

Animal	Brain Weight (g)
Dog	70
Hippopatamus	580
Lion	240
Orangutan	370
Horse	530
Camel	760
Beaver	45
Pig	180

Animal Horn Length (Centimeters)

Animal	Horn Length (cm)
Water Buffalo	420
Rhinoceros	90
Texas Longhorn	230
Markor	150
Addax	110
Saiga	22
Mouflon	65
Giant Eland	125

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Inspector Graph-It

Snapshot

Students play with finding errors in data by looking for what doesn't make sense. Partners construct their own set of faulty data and then try to detect errors in the data displays created by the rest of the class.

Connection to CCSS
3.MD.3

Agenda

Activity	Time	Description/Prompt	Materials
Launch	10 min	Show students the Animal Height Graph and Table and discuss students' observations. Ask students to read and evaluate carefully. Sometimes there are mistakes, and we love mistakes!	Animal Height Graph and Table, to display
Explore	30 min	Partners work together to construct a faulty data set, one with both accurate and inaccurate data. Partners create a display of this data that includes a table and a graph.	• Chart paper and markers • Make available: classroom data resources, such as nonfiction books, and measurement tools
Play	15–20 min	Post students' faulty data charts. Students play Inspector Graph-It by rotating around the classroom from chart to chart trying to detect all the errors in each display. Students record the errors they find as they go.	Tools for writing while walking around the room, such as notebooks or clipboards
Discuss	15–20 min	Discuss the errors the class found hidden in each chart, and check with the authors of the chart that the class found them all. Discuss how students hunted for errors and how they had to think to construct a faulty data set.	Optional: marker or highlighter to mark errors on the charts

To the Teacher

In this activity, we encourage students to be critical of data by hunting for errors. We've created a table and graph that include two kinds of errors. First, there are places in which the graph and table do not match. Students may not be able to determine which, or if either, is correct. However, they should detect the discrepancy and conclude that some error exists. The second kind of error is one of logic. Again, students may not know the actual data, but they likely know that a hippopotamus is not a lot shorter than a tiger. When the data shows the opposite, this should arouse students' suspicion. Encourage students to develop a critical eye on data and to constantly ask, Does this make sense?

Activity

Launch

Launch the lesson by showing students the Animal Height Graph and Table on a projector. Ask students what they notice in the data. Give students a moment to turn and talk to a partner about their observations. Collect some noticings, and be sure to ask students to come up to point out where their observation or inference came from in the data. Students may notice errors at this stage, or they may not. If they do, draw attention to the error, and ask other students if they agree that it does not make sense.

Ask students to read the graph and table carefully. Sometimes there are mistakes, and we love mistakes. Remind students that we should always read graphs and tables in an inquisitive way and not just assume they are accurate. Give students another opportunity to turn and talk, this time focusing on finding errors in the data. Discuss what students notice and their reasoning behind their conclusions. Focus on the reasoning and how students know something doesn't make sense. Be sure students have attended to both kinds of errors in the data—discrepancies between the table and graph and logical errors.

Explore

Ask students to work in partners to create their own faulty data. They must create a data set, with both a table and graph, that includes some true data and some errors. The errors can be discrepancies between the table and graph, logical errors where the data doesn't make sense, or both. Partners need to first consider what kind of data

they would like to display. Students can collect data in the classroom or from available resources. For instance, students could measure the heights of furniture in your classroom or use a nonfiction text to find out the speeds of land mammals. However, students should be careful that the errors they put into their data should be the kind that someone could notice by looking carefully and thinking about the data, rather than by knowing facts.

Partners construct a table and graph to show the data set on chart paper. The data should include titles and labels to make the data clear. Partners should make a list that they can keep to themselves of the errors they have hidden in the data.

Play

Post partners' data charts around the room. Each chart should also be clearly labeled with the names of the students who created it. Play Inspector Graph-It by having partners rotate around the room, taking a few minutes at each chart to try to catch the errors in the data displayed. Encourage students to be detectives and hunt down every error they can. Ask students to jot down in their notebooks or on clipboards the errors they find for each data display as they rotate. For instance, students might record that Tupa and Kia's data of animal weights has an error because a rhino is not lighter than an iguana.

Discuss

Discuss each chart, asking the class what errors they found in the data. The partners who created the chart being discussed should have out the list of errors they put into the data and check them off as the class names them. You may want to use a colored marker or highlighter to mark these errors on the charts as the class catches them. After the class has discussed all the errors they found together, ask the authors of the data set whether there were any flaws the class missed.

Discuss the following questions:

- How did you have to think about the data to catch errors?
- What kinds of errors were hardest for you to catch? Why do you think that is?
- What did you have to think about to construct the faulty data?

Look-Fors

- **Are students noticing errors of both kinds?** During the launch, you'll want to be sure students have noticed both discrepancies and logical errors in the data.

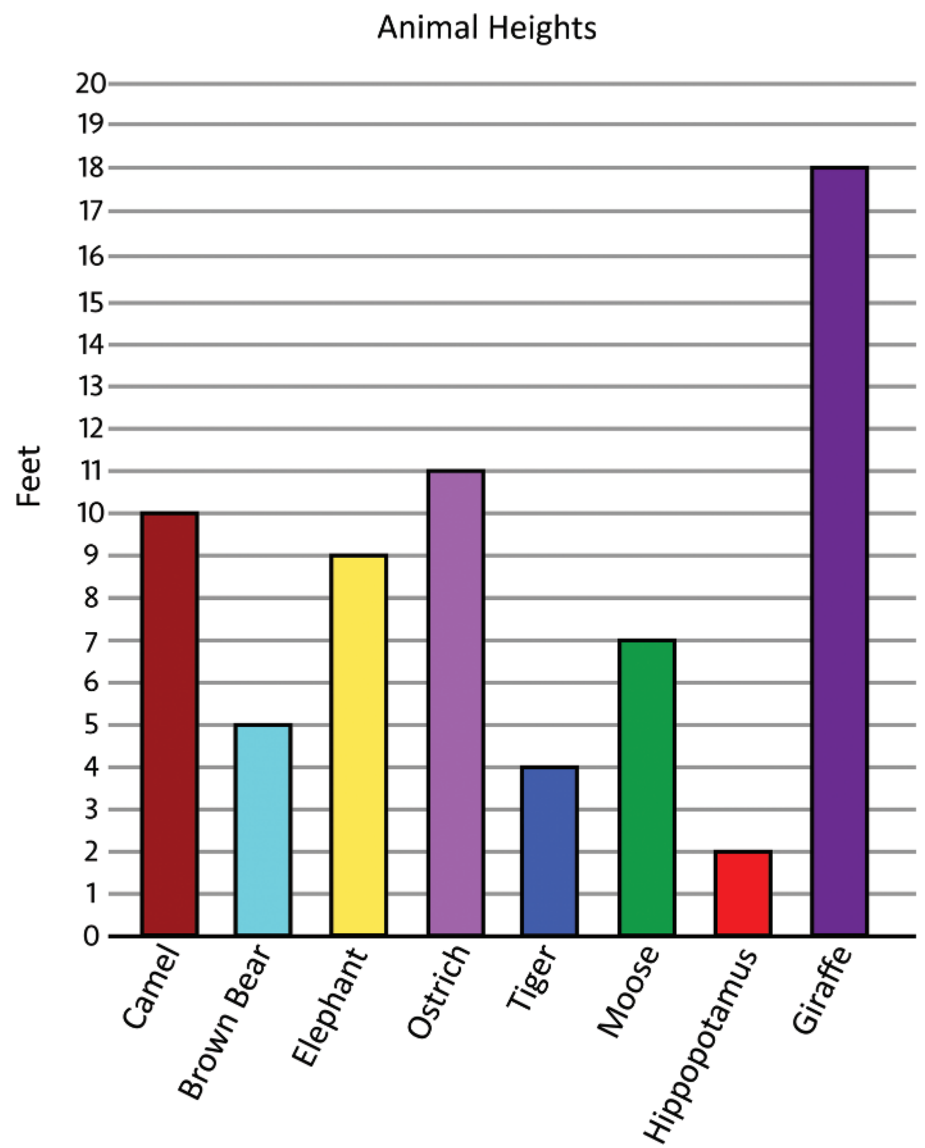
Rather than having students head off to find a resource to check each data point—a strategy that would likely identify errors but is inefficient to use regularly—support students in using what they already know to ask, Does this make sense? How are the data points related? Do those relationships make sense? How are the table and graph related? Are they consistent?

- **Are students constructing data sets that have accuracies?** In the excitement to make a fake data set, students may overlook using accurate data as well. Having both accurate and inaccurate data mixed together makes finding the errors harder, and we all like a good challenge. Be sure students are starting with an accurate set of data—for example, counts of objects in your classroom or information from a book on a topic the class is investigating in science. Then ask students how they could change the data to create errors.
- **Are students constructing data sets with errors that could be detected by other students?** When students try to be good and sneaky with their data set, they might make only very slight changes to the data, such that no one would be able to detect the error. As you talk to students while they are constructing their data sets, ask them about the errors they are putting into the data. Ask them if they think others would be able to spot the mistake using what they already know. For instance, the class should be able to figure out that a classroom chair is not 100 inches tall, but they may not be able to tell whether the chair is actually 20 or 22 inches high.
- **How are students justifying the errors they see?** When students claim they have found an error, be sure to press them to explain their reasoning. They should be able to draw on reasoning that others will understand and share. For instance, a student should be pointing to the two data points in the graph and table that should match but do not. For logical errors, students might draw on prior knowledge of the object itself (such as, "I know the table is about 2 feet tall.") or comparative knowledge (such as, "I know the table is shorter than the bookcase" or "I know the table is about half my height, and I'm 4 feet tall"). Both kinds of reasoning are valuable and should be highlighted so that others can draw on these kinds of reasoning.

Reflect

How do you know when data doesn't make sense?

Animal Height Graph and Table



Animal	Feet
Camel	10
Brown Bear	5
Ostrich	9
Elephant	11
Tiger	4
Moose	7
Hippopotamus	2
Giraffe	18

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Data Tells Us about Ourselves

Snapshot

What is the most common car color where you live? Students develop and try out a data collection plan to answer this question, and then look across the data collected by the whole class to see what can be learned from the similarities and differences. We offer two options for multiday extensions that put students in charge of using data to investigate their school or community.

Connection to CCSS
3.MD.3

Agenda

Activity	Time	Description/Prompt	Materials
Launch	10–15 min	Show students the Parking Lot Photo and invite observations. Ask students to predict, What is the most common car color in our area? As a class, develop a data collection plan that would help answer this question.	Parking Lot Photo, to display
Explore	30+ min	Partners work together to implement the class's data collection plan. Students develop ways to organize and display the data. Partners make observations and use their evidence to come to a conclusion, which they include on a display.	• Charts and markers • Data collection and display tools, such as clipboards, grid paper (see appendix), and tape
Discuss	20 min	Do a gallery walk of all the data and conclusions from all partnerships. Discuss the similarities and differences in the data the groups collected, and what may have led to differences. Come to a class conclusion about the most common car color in your area.	

(*Continued*)

Activity	Time	Description/Prompt	Materials
Extend	Varies: 2+ days	Two choices are offered for extension: investigation of a classroom- or school-based question, or the development of a community-based research project. Both require defining a question, developing a data collection plan, collecting and displaying data, and coming to a conclusion to share.	Data collection and display tools, such as clipboards, grid paper (see appendix), tape, charts, and markers

To the Teacher

In this investigation, we have approached developing the skills to use data to answer questions with a question we think any class could reasonably ask and answer with locally gathered data: What is the most common car color in your area? We aim to support students to develop a plan for collecting and examining data that helps them address the question. We encourage you to think about the ways that the physical location and resources of your school site might give students opportunities to collect data. Can you see cars driving by your classroom window? Do they go by often enough to get a real sample in a reasonable time? Does your school have a large (and, we hope, calm) parking lot? Is there parallel parking on the street in front of your school? Could you take students on a walking tour of your neighborhood to tally parked cars? We have not dictated a plan in this lesson because students should develop the plan, and it must be reasonable in your context. Thinking through the logistics of data collection in advance will help you respond to students' ideas and take up those that are safe and reasonable.

Students do not need to all use the same plan or collect data simultaneously. You might decide to break the class into smaller groups to do data collection in shifts. The differences in the data the groups collect will only add to the later whole-class discussion. Partners should be in charge of deciding how much data they need, and, to the extent that is practical, we encourage you to give students choices about how to collect the data. For instance, some students may want to just collect from one full row of the parking lot, while others want to do the back half, and still others want to try to count them all. These different choices will give your class lots to talk about in the end.

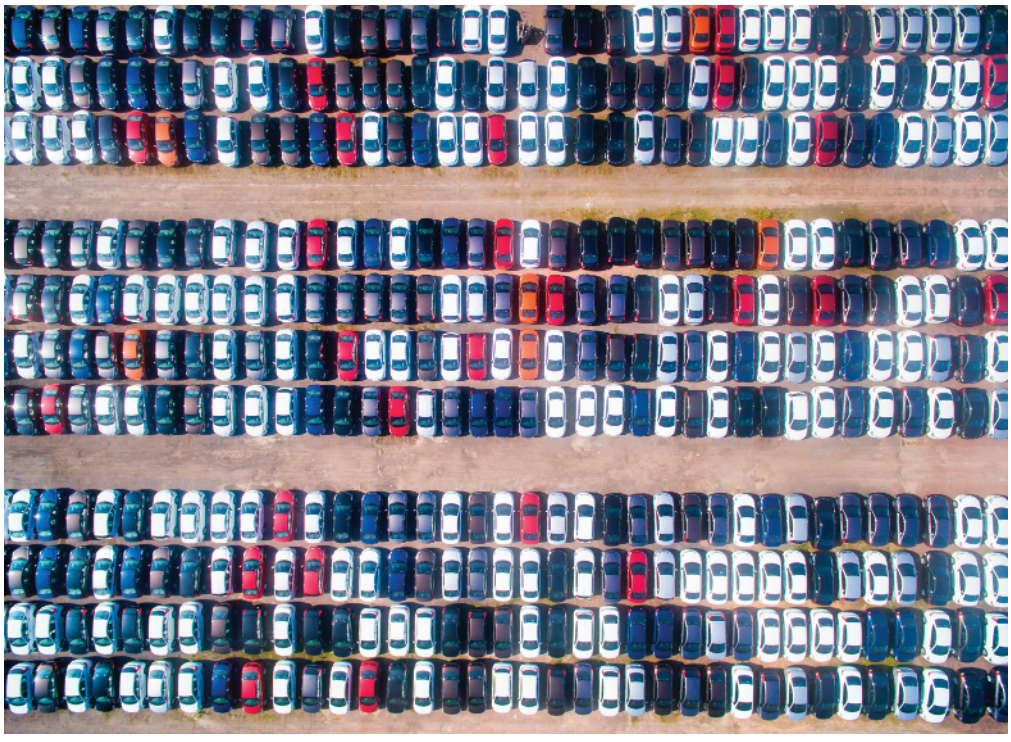
We think this initial investigation will give students many opportunities to learn about using data from the real world to answer questions, but we recognize the limitations of the specific question we've posed. Students will be far more motivated to

collect and analyze data if they are attempting to answer their own questions. In the extension of this lesson, we've offered two different ideas for multiday investigations of authentic questions. Students will build on what they learn investigating the car question to pose and research their own questions. These extensions are open ended and take some planning to tailor them to the opportunities in your school and community. We think it's worth the work. Students often have data thrust at them, or gain experience with data conducting surveys of things they aren't really invested in. We think choosing one of the extension options here will give students avenues for seeing the power of data in the real world.

Activity

Launch

Launch by showing students the Parking Lot Photo and asking them what they notice. Give students a chance to turn and talk, and then take students' observations. Note that students may notice things about how the cars are arranged and the colors. Probe students to provide some evidence for their observations, particularly observations that compare (such as, "There are more white cars than orange.") or estimate (such as, "I think there are more than 100 cars there.").



Source: Image by Shutterstock.com/Aleksei Kazachok.

Pose the question, What is the most common car color in our area? Ask students to make a prediction based on the photo or what they know. Ask students to share their predictions and their reasoning. Be sure to make connections between their evidence and their prediction. For instance, students might say that they predict white is the most common because of all the white cars in the photo. You would want to make the connection clear that they are only seeing some cars, but they think that this photo represents all cars. You might ask them if they think this photo would match the cars where you live.

Ask, How could we collect data to answer this question? Tell students that you don't have a photo like this one taken where you live, so you will need a different way to collect data to answer the question. Possibilities include counting cars in the parking lot, cars parallel parked on the street in front of the school, or cars as they drive by. Work together to come up with either one shared plan for the class or a couple of possibilities that you can reasonably support.

Explore

Students work in partners to collect data following the class plan or choosing from the plans the class developed. Students need to figure out a way to record the data they collect, organizing it so they can use it to make conclusions. You may want to take students out of the building to do a walking survey of cars in a particular area, or students may be able to observe cars through the classroom window or from another indoor vantage point.

Once partners have collected what they think is enough data, they need to design a way to display the data to help answer the question, What is the most common car color in our area? Students should be encouraged to display all of their data, even the data for colors that are less popular, so that the class can make comparisons later. Their displays should include all data, their conclusion about the most popular color, and how their data supports that conclusion.

Discuss

Have students post their displays, including any graph and table data they have, their conclusions, and their supporting evidence. Do a gallery walk, in which students walk around and look at the different displays and conclusions. As they walk, student should be thinking about the following questions:

- How is our data similar?
- How is our data different? Why might our data be different?
- What appears to be the most common color in our area?

Discuss the differences and similarities in the data collected by the different groups, and ideas about why the data might not be the same. Ask students:

- What conclusions can we draw about the most common color in our area?
- What data did you find most convincing? Why?
- What other data would we want to collect to be sure?

Extend

There are two possibilities for extension, depending on what would excite your students:

1. Ask students to pose their own question about their school or community that they could reasonably collect data to answer. Note that students are often encouraged to ask questions that focus on favorites, but in this investigation, we'd like to go beyond making conclusions about what the students in one class like, toward being able to think about the school, neighborhood, or community. Work with students to generate questions that intrigue them and where data could be collected, such as:
   - How much waste is created by each grade level (or class or lunch period) at lunch?
   - Which lunches do the teachers eat? Which lunches do the kids eat?
   - How do kids get to school?
   - What do kids do after school? How does that change each day?
   - How much paper does each class recycle?
   - How much litter is left in each hallway (or in front of each classroom) each day?
   - What books are checked out each week from the library?

   Note that these are just examples, and we encourage you to brainstorm as a class. Students should make a prediction (or hypothesis) about the question and then devise a way to collect the needed data. Students will then need to create a display and a way to share. Students should make observations about their data that help answer their question or notice surprising findings. Create

time for each group to share what they have found and for the class to ask questions.

2. Identify an area in your school, classroom, or community that genuinely needs research for decision making. This could be something like designing a new playground, determining what new books to order for the classroom or school library, planning for a school or classroom event (such as back-to-school night or a party), or making a recommendation to the community or town on a new project (such as putting together a softball league, planning for a community garden, or dealing with a community space that is not well cared for or used). Here the extension is more involved and more authentically similar to the work researchers do. Students need to:
   - Define the question(s) that need to be explored.
   - Determine how to gather data to answer those questions. Whom can we ask? Where can we find the data?
   - Collect data and determine how to represent the data so that observations can be made.
   - Determine what the data does and does not tell about the questions that were asked.
   - Make a recommendation based on the data to support the decision making.
   - Present their findings to an audience.

   Although planning for and executing this extension could take considerable time, we think students would be deeply engaged in supporting an authentic decision-making process with data and recommendations.

Look-Fors

- **How are students deciding what cars to sample?** Sampling is not a concept that we typically discuss with students in elementary school, but the question we have asked about common car color is one where sampling matters. You'll likely only have access to a sample near your school, of cars either parked nearby or driving past, but students do have a choice of how many cars to sample before they decide they have enough data. Certainly, 5 or 6 cars isn't enough, and a thousand is not necessary. So, how many cars are enough for you to feel confident in your conclusion? This is a great question to be discussing with students as they collect data, and it will create useful variation among

the different groups' data to discuss. The sample size is one factor that will contribute to differences among the data sets, and possibly the conclusions.

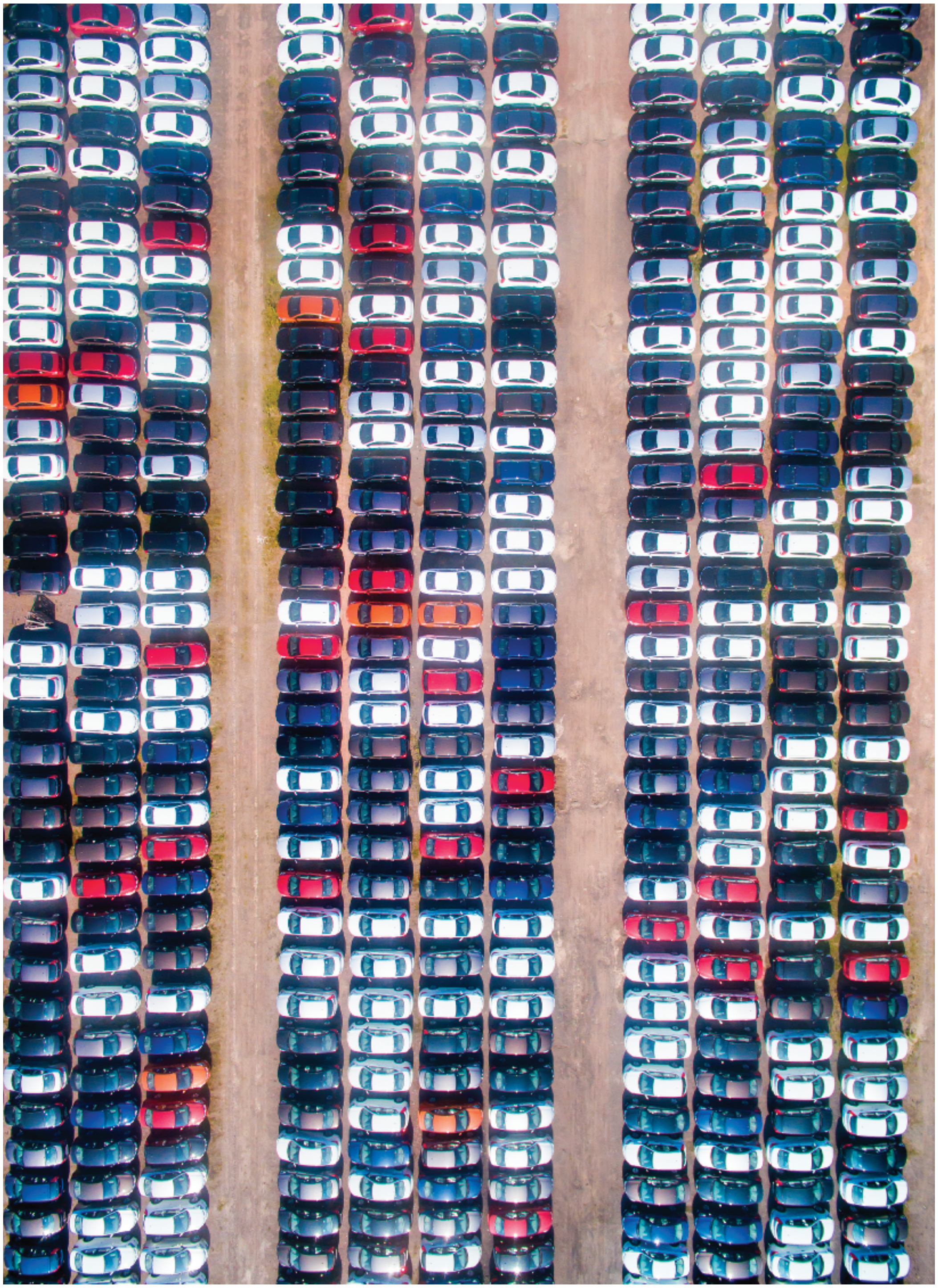
- **What categories are students using for classifying their data?** Students who use large categories, such as *blue,* will get different results from those who use finer categories, such as *light blue, navy,* and *teal.* There is no single correct way to create the categories, but consistency is valuable. If students use small categories for some of their data, they should use small categories across their data, where possible. You may want to ask students how they are deciding on the categories and whether they agree on what each category means. There are always marginal cases that need to be resolved, and partners should agree on how to categorize each car.
- **Do students' data displays match and make sense?** As we worked on in the previous activities in this big idea, different representations of the same data set should match and make sense. It would be surprising for students all to enter the same parking lot and come out with wildly conflicting data. Further, after students tally up the cars, there are lots of opportunities for inadvertent errors to creep in, from counting to recording to displaying. Ask students how they are making sure their data is accurate. Draw students' attention to any discrepancies and help them reason through how these crept in and where the accurate data most likely is.
- **How are students supporting their conclusions with evidence?** Regardless of the questions students are investigating, they need to use the data reasonably to support conclusions. Students should pick out useful parts of the data to help them address the questions asked. They also need to recognize when multiple answers are reasonable. For instance, if your car survey ends with 42 white cars and 39 blue cars, it would be difficult to claim confidently that white is the most popular, because the two values are too close to be sure. If you notice that your data yields two close leading values, draw the class's attention to what this data means, with particular emphasis on what it *could* mean. In this case, it *could* mean that blue is just as popular as white. This is where we return to the importance of the sample; this is not an election where every vote gets counted and even one vote can create a winner. Here we are getting a small slice of the real data, just a glimpse, and our conclusions need to acknowledge this. If you really want to know which is the most popular, it may mean you need to collect more data. If it is reasonable, encourage students to

do just that. If, in the end, the data shows that it is too close to call, this is a conclusion that can be defended with the data.

Reflect

What kinds of questions can data help us answer? How do you decide what data to collect to answer your questions?

Parking Lot Photo



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