Lesson 6

Interpreting Histograms

Goals

- Compare and contrast (orally) dot plots and histograms in terms of how useful they are for answering different statistical questions.
- Create a histogram to represent a data set.
- Interpret a histogram to answer (in writing) statistical questions about a data set.

Learning Targets

- I can recognize when a histogram is an appropriate graphical display of a data set.
- I can use a histogram to get information about the distribution of data and explain what it means in a real-world situation.

Lesson Narrative

In this lesson students are introduced to **histograms.** They learn that, like a dot plot, a histogram can be used to show the distribution of a numerical data set, but unlike a dot plot, a histogram shows the frequencies of groups of values, rather than individual values. Students analyze the structures of dot plots and histograms displaying the same data sets and determine what information is easier to understand from each type of display. Students read and interpret histograms in context to prepare them to create a histogram.

Student Learning Goal

Let's explore how histograms represent data sets.

Access for Students with Diverse Abilities

- Action and Expression (Activity 2)
- Representation (Activity 1)

Access for Multilingual Learners

- MLR2: Collect and Display (Activity 1)
- MLR8: Discussion Supports (Activity 2)

Instructional Routines

- MLR2: Collect and Display

Required Materials

Materials to Gather

- Straightedges: Activity 2

Lesson Timeline

Warm-up	Activity 1	Activity 2	Lesson Synthesis	Assessment
5 min	10 min	20 min	10 min	5 min
				Cool-down

Warm-up

Dog Show (Part 1)

5 min

Activity Narrative

The purpose of this *Warm-up* is to connect the analytical work that students have done with dot plots in previous lessons with statistical questions. This activity reminds students that we gather, display, and analyze data in order to answer statistical questions. This work will be helpful as students contrast dot plots and histograms in subsequent activities.

Launch

Arrange students in groups of 2. Give students 1 minute of quiet work time, followed by 2 minutes to share their responses with a partner. Ask students to decide, during a partner discussion, if each question proposed by their partner is a statistical question that can be answered using the dot plot. Follow with a whole-class discussion.

If students have trouble getting started, consider giving a sample question that can be answered using the data on the dot plot (for example, "How many dogs weigh more than 100 pounds?")

Student Task Statement

Here is a dot plot showing the weights, in pounds, of 40 dogs at a dog show.

1. Write two statistical questions that can be answered using the dot plot.

   Sample questions:

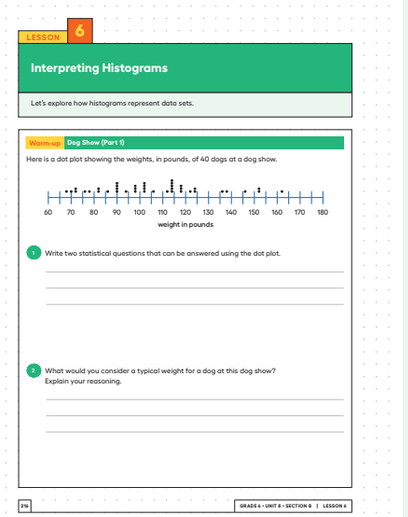
   - How many dogs weigh exactly 70 pounds?
   - How many dogs weigh more than 80 pounds but less than 150 pounds?
   - How much does the heaviest dog at the dog show weigh?
   - How many times as heavy as the lightest dog is the heaviest dog?
   - How alike or different are the weights of the dogs at the show?

2. What would you consider a typical weight for a dog at this dog show? Explain your reasoning.

   Sample responses:

   - About 114 pounds, because the largest percentage of the dots are at 114, and it seems to be about where the center of the data is
   - About 100 pounds, because about half of the dogs are 100 pounds or lighter, and half are heavier than 100 pounds

Student Workbook


LESSON 6

Interpreting Histograms

Let's explore how histograms represent data sets.

Warm-up: Dog Show (Part 1)

Here is a dot plot showing the weights, in pounds, of 40 dogs at a dog show.

60 70 80 90 100 110 120 130 140 150 160 170 180

weight in pounds

1. Write two statistical questions that can be answered using the dot plot.

2. What would you consider a typical weight for a dog at this dog show? Explain your reasoning.

Instructional Routines

MLR2: Collect and Display

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Please log in to the site before using the QR code or URL.

Access for Multilingual Learners (Activity 1)

MLR2: Collect and Display. This activity uses the *Collect and Display* math language routine to advance conversing and reading as students clarify, build on, or make connections to mathematical language.

Activity Synthesis

Ask students to share questions that they agreed were statistical questions that could be answered using the dot plot. If there is time, consider asking students how they would find the answer to some of the statistical questions.

Display the dot plot for all to see. Ask students to share a typical weight for a dog at this dog show and why they think it is typical. Mark their answers on the displayed dot plot. After each student shares, ask the class if they agree or disagree.

Activity 1
Dog Show (Part 2)

10 min

Activity Narrative

This activity introduces students to **histograms**. By now, students have developed a good sense of dot plots as a tool for representing distributions. They use this understanding to make sense of a different form of data representation. The data set shown on the first histogram is the same one from the preceding *Warm-up*, so students are familiar with its distribution. This allows them to focus on making sense of the features of the new representation and comparing them to the corresponding dot plot.

At this point students do not yet need to see the merits or limits of histograms and dot plots. Students should recognize, however, how the structures of the two displays are different and start to see that the structural differences affect the insights we are able to glean from the displays.

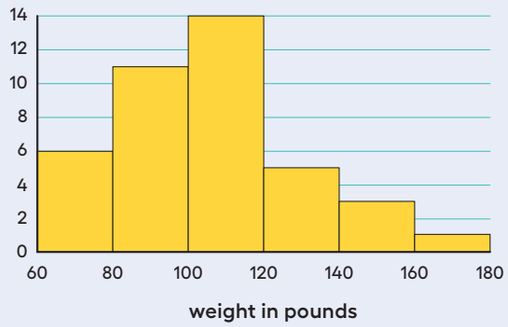
Launch

Explain to students that they will now explore histograms, another way to represent numerical data. Give students 3–4 minutes of quiet work time, and then 2–3 minutes to share their responses with a partner. Follow with a whole-class discussion.

Use *Collect and Display* to create a shared reference that captures students' developing mathematical language. Collect the language that students use to discuss how dot plots and histograms are alike and different. Display words and phrases such as "precise," "frequency," "distribution," "center," and "spread."

Student Task Statement

Here is a **histogram** that shows some dog weights in pounds.



Each bar includes the left-end value but not the right-end value. For example, the first bar includes dogs that weigh 60 pounds and 68 pounds but not 80 pounds. An 80-pound dog would be included in the second bar with a frequency of 11.

1. Use the histogram to answer these questions.

a. How many dogs weigh between 100 and a little less than 120 pounds?

14 dogs

b. How many dogs weigh exactly 70 pounds?

Unknown. It could be anywhere between 0 and 6.

c. How many dogs weigh at least 120 pounds?

9 dogs

d. How much does the heaviest dog at the show weigh?

The exact weight cannot be determined, but it weighs at least 160 pounds but less than 180 pounds.

e. What would you consider a typical weight for a dog at this dog show? Explain your reasoning.

Sample response: Around 100 pounds. The largest percentage (35%) of the weights fall in the third bar (at least 100 pounds and less than 120 pounds), and it is approximately the middle of the data.

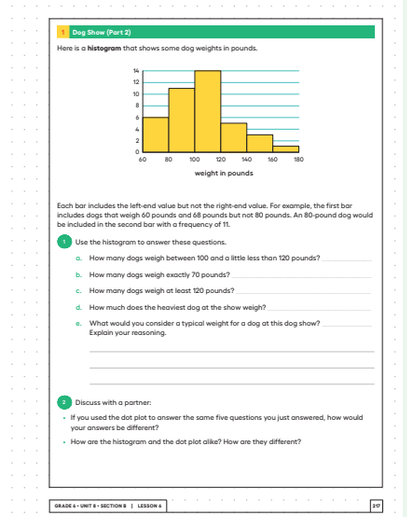
2. Discuss with a partner:

- If you used the dot plot to answer the same five questions you just answered, how would your answers be different?
- How are the histogram and the dot plot alike? How are they different?

Sample responses:

- They are alike in that they are both built on number lines, show the same total number of data values, and show how the values are spread out. They are different in that the dot plot shows individual data points and the histogram groups the data points together.
- With the dot plot we can see the values of individual points and tell how many there are. With the histogram, we can't tell how many data points have specific values. We know only how many points fall into a specific range.

Student Workbook


1 Dog Show (Part 2)

Here is a **histogram** that shows some dog weights in pounds.

Each bar includes the left-end value but not the right-end value. For example, the first bar includes dogs that weigh 60 pounds and 68 pounds but not 80 pounds. An 80-pound dog would be included in the second bar with a frequency of 11.

1 Use the histogram to answer these questions.

a. How many dogs weigh between 100 and a little less than 120 pounds? _____

b. How many dogs weigh exactly 70 pounds? _____

c. How many dogs weigh at least 120 pounds? _____

d. How much does the heaviest dog at the show weigh? _____

e. What would you consider a typical weight for a dog at this dog show? Explain your reasoning. _____

2 Discuss with a partner:

- If you used the dot plot to answer the same five questions you just answered, how would your answers be different?
- How are the histogram and the dot plot alike? How are they different?

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Access for Students with Diverse Abilities (Activity 1, Synthesis)

Representation: Develop Language and Symbols.
Maintain a display of important terms and vocabulary. Invite students to suggest language or diagrams to include that will support their understanding of displays of data. Terms may include "dot plot" and "histogram."

Supports accessibility for: Conceptual Processing, Language

Activity Synthesis

Ask a few students to briefly share their responses to the first set of questions to make sure that students are able to read and interpret the graph correctly.

Then direct students' attention to the reference created using *Collect and Display*. Ask students to share their comparison of dot plots and histograms. Invite students to borrow language from the display as needed, and update the reference to include additional phrases as they respond. (For example, "The histogram is less precise, but you can still see the distribution. The center and spread appear similar in both.")

If not already mentioned by students, highlight that, in a histogram:

- Data values are grouped into intervals or "bins" and represented as vertical bars.
- The height of a bar reflects the combined frequency of the values in that bin.
- A histogram uses a number line.

Activity 2

Population of States

20 min

Activity Narrative

In this activity, students continue to develop their understanding of histograms. They begin to notice that a dot plot may not be best for representing a data set with a lot of variability or when a data set has a large number of different values. Histograms may help one visualize a distribution more clearly in these situations. Students organize a data set into bins and draw a histogram to display the distribution.

As students work and discuss, listen for explanations for why certain questions might be easy, hard, or impossible to answer using each graphical display.

Launch

Give students a brief overview of census and population data because some students may not be familiar with them. Display, for all to see, the dot plot and problem stem, "Every ten years, the United States conducts a census, which is an effort to count the entire population. The dot plot shows the population data from the 2010 census for each of the fifty states and the District of Columbia (DC)." Discuss questions such as:

- *"How many total dots are there?"*

  51

- *"What's the population of the state with the largest population? Do you know what state that is?"*

  Between 37 and 38 million. It's California.

- *"Look at the leftmost dot. What state might it represent? Approximately what is its population?"*

  The leftmost dot represents Wyoming, with a population of around half a million.

"Do you know the approximate population of our state? Where do you think we are in the dot plot?"

Explain to students that they will now draw a histogram to represent the population data. Remind them that histograms organize data values into "bins" or groups. In this case, the bin sizes are already decided for them. Next, arrange students in groups of 3–4. Provide access to straightedges. Give students 10–12 minutes to complete the activity. Encourage them to discuss their work within their group as needed.

Student Task Statement

Every ten years, the United States conducts a census, which is an effort to count the entire population. The dot plot shows the population data from the 2010 census for each of the fifty states and the District of Columbia (DC).

1. Here are some statistical questions about the population of the fifty states and DC. How difficult would it be to answer the questions using the *dot plot*?

   In the middle column, rate each question on its difficulty to answer based on this dot plot as either easy, hard, or impossible. Be prepared to explain your reasoning.

statistical question	using the dot plot	using the histogram
a. How many states have populations greater than 15 million?	Easy	Easy
b. Which states have populations greater than 15 million?	Impossible	Impossible
c. How many states have populations less than 5 million?	Impossible	Easy
d. What is a typical state population?	Hard	Hard
e. Are there more states with fewer than 5 million people or more states with between 5 and 10 million people?	Hard	Easy
f. How would you describe the distribution of state populations?	Hard	Easy

a. Sample response: Unless some dots are lying directly on top of one another, there are four states with a population greater than 15 million.

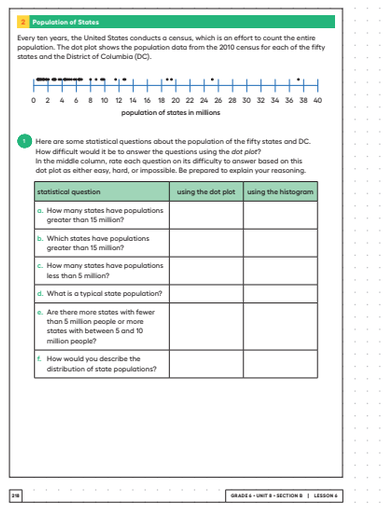
b. Sample response: Since the dots are not labeled, it is impossible to tell which states have a population greater than 15 million.

Access for Students with Diverse Abilities (Activity 2, Student Task)

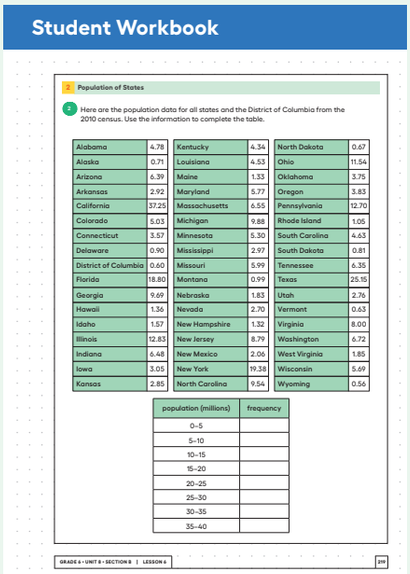
Action and Expression: Internalize Executive Functions.
To support development of organizational skills in problem-solving, chunk this task into more manageable parts. For example, have students focus on the first question. Next, have them focus on the frequency table and histogram creation. Finally, have them return their focus to the initial table.

Supports accessibility for: Organization, Attention

Student Workbook



Student Workbook



2 Population of States

2 Here are the population data for all states and the District of Columbia from the 2010 census. Use the information to complete the table.

Alabama	4.78	Kentucky	4.34	North Dakota	0.67
Alaska	0.71	Louisiana	4.53	Ohio	11.54
Arizona	6.39	Maine	1.33	Oklahoma	3.75
Arkansas	2.92	Maryland	5.77	Oregon	3.83
California	37.25	Massachusetts	6.55	Pennsylvania	12.70
Colorado	5.03	Michigan	9.88	Rhode Island	1.05
Connecticut	3.57	Minnesota	5.30	South Carolina	4.63
Delaware	0.90	Mississippi	2.97	South Dakota	0.81
District of Columbia	0.60	Missouri	5.99	Tennessee	6.35
Florida	18.80	Montana	0.99	Texas	25.15
Georgia	9.69	Nebraska	1.83	Utah	2.76
Hawaii	1.36	Nevada	2.70	Vermont	0.63
Idaho	1.57	New Hampshire	1.32	Virginia	8.00
Illinois	12.83	New Jersey	8.79	Washington	6.72
Indiana	6.48	New Mexico	2.06	West Virginia	1.85
Iowa	3.05	New York	19.38	Wisconsin	5.69
Kansas	2.85	North Carolina	9.54	Wyoming	0.56

population (millions)	frequency
0–5	
5–10	
10–15	
15–20	
20–25	
25–30	
30–35	
35–40	

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c. Sample response: Since the dots are so close together below 5 million, it's impossible to count how many there are.

d. Sample response: Since so many dots are indistinguishable, it's hard to determine a typical state population.

e. Sample response: It appears that there are more dots for populations that are less than 5 million than for those between 5 and 10 million, but we can't be sure because dots might be right on top of each other.

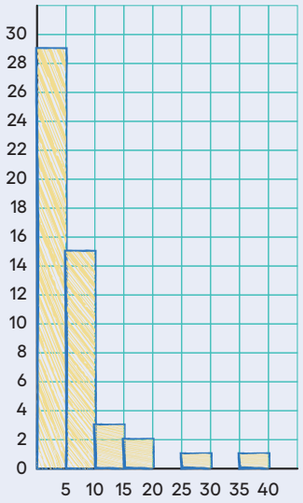
f. Sample response: Since the dots overlap a lot, it is difficult to give a good estimate for the center and spread.2.

2. Here are the population data for all states and the District of Columbia from the 2010 census. Use the information to complete the table.

Alabama	4.78	Kentucky	4.34	North Dakota	0.67
Alaska	0.71	Louisiana	4.53	Ohio	11.54
Arizona	6.39	Maine	1.33	Oklahoma	3.75
Arkansas	2.92	Maryland	5.77	Oregon	3.83
California	37.25	Massachusetts	6.55	Pennsylvania	12.70
Colorado	5.03	Michigan	9.88	Rhode Island	1.05
Connecticut	3.57	Minnesota	5.30	South Carolina	4.63
Delaware	0.90	Mississippi	2.97	South Dakota	0.81
District of Columbia	0.60	Missouri	5.99	Tennessee	6.35
Florida	18.80	Montana	0.99	Texas	25.15
Georgia	9.69	Nebraska	1.83	Utah	2.76
Hawaii	1.36	Nevada	2.70	Vermont	0.63
Idaho	1.57	New Hampshire	1.32	Virginia	8.00
Illinois	12.83	New Jersey	8.79	Washington	6.72
Indiana	6.48	New Mexico	2.06	West Virginia	1.85
Iowa	3.05	New York	19.38	Wisconsin	5.69
Kansas	2.85	North Carolina	9.54	Wyoming	0.56

population (millions)	frequency
0–5	29
5–10	15
10–15	3
15–20	2
20–25	0
25–30	1
30–35	0
35–40	1

3. Now, use the grid and the information in your table to create a *histogram*.



4. Return to the statistical questions at the beginning of the activity. Which ones are now easier to answer?

Complete the table, rating the difficulty of answering each question—this time using your histogram. Be prepared to explain your reasoning.

Revisiting the questions from the first problem:

a. Sample response: Still easy.

b. Sample response: Still impossible, based on the histogram alone.

c. Sample response: Now it is easy to tell how many states had a population below 5 million. It was previously impossible.

d. Sample response: From the histogram, we can estimate that a typical state population has fewer than 10 million, but it is hard to be more precise than that at this point. It was previously hard.

e. Sample response: Using the histogram it is easy to tell how many states have fewer than 5 million people and how many have between 5 and 10 million (there are more states in the smaller population category). It was previously hard.

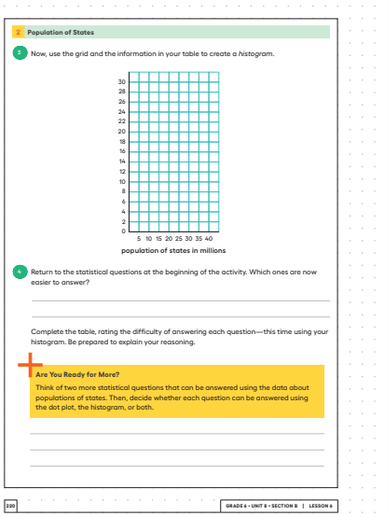
f. Sample response: It is easier to describe the data distribution more precisely because the histogram shows the population sizes in intervals of 5 million people.

Are You Ready for More?

Think of two more statistical questions that can be answered using the data about populations of states. Then, decide whether each question can be answered using the dot plot, the histogram, or both.

Answers vary.

Student Workbook



Access for Multilingual Learners (Activity 2, Synthesis)

MLR8: Discussion Supports. Display a sentence frame to help students make decisions about the type of graph to use to display different types of data sets: "Histograms are easy (or hard or impossible) to use when _____, because ..."

Advances: Conversing, Representing

Activity Synthesis

Much of the discussion about how to construct histograms should have happened in small groups. Address unresolved questions about drawing histograms if they are relatively simple. Otherwise, consider waiting until students have more opportunities to draw histograms in upcoming lessons.

Focus the discussion on comparing the effectiveness of dot plots and histograms to help us answer statistical questions.

Select a few students or groups to share how their ratings of easy, hard, and impossible, changed when they transitioned from using dot plots to using histograms to answer statistical questions about populations of states. Then discuss and compare the two displays more generally. Solicit as many ideas and observations as possible regarding these questions:

- *"When might histograms be preferable to dot plots?"*

  It can be easier to see general trends when grouping similar values together when the data have a large number of different values.

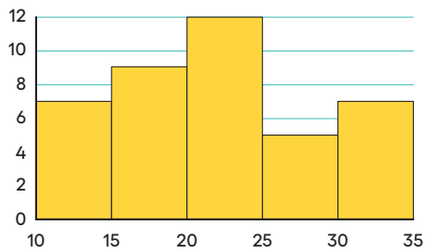
- *"When might dot plots be preferable to histograms?"*

  When it is important to remain precise about the actual values of the data.

By grouping similar values together, a histogram can sometimes show general trends better than dot plots can. The individual precision is lost in a histogram, so if that information is important, it may be worth using a dot plot.

Lesson Synthesis

A **histogram** is a visual representation of data that groups values together in intervals or "bins" to combine their frequency. This histogram, for instance, represents the distribution for the weights of some dogs.



dog weights in kilograms

- *"What could the smallest dog weigh? The largest?"*

  10 kilograms up to almost 35 kilograms

- *"What does the bar between 25 and 30 tell you?"*

  5 dogs weigh between 25 and just under 30 kilograms

- *"What can you say about the dogs who weigh between 10 and 20 kg?"*

  There are 16 total dogs in this range, including 7 dogs between 10 and 15 kg and 9 between 15 and 20 kg

- *"In general, what information does a histogram allow us to see? How is it different from a dot plot?"*

  A bigger picture of the distribution is shown in the histogram, but some of the detail is lost when compared to a dot plot. For example, this histogram does not show the weight of any individual dogs.

"What are some advantages of using a histogram instead of a dot plot?"

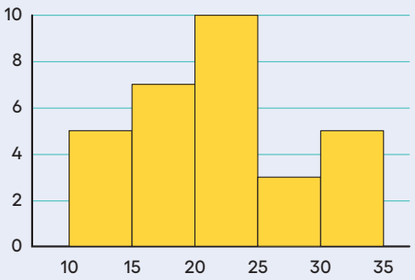
A histogram is useful for looking at general trends by grouping a range of values together into a single frequency. When the data are very spread out, when there are not very many data points with the same value, or when an overall idea of the distribution is more important than a detailed view, a histogram may be more useful than a dot plot.

Lesson Summary

In addition to using dot plots, we can also represent distributions of numerical data using **histograms.**

Here is a dot plot that shows the weights, in kilograms, of 30 dogs, followed by a histogram that shows the same distribution.

dog weights in kilograms



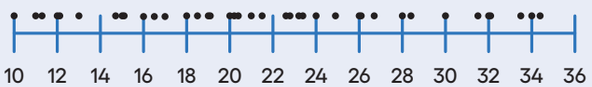
dog weights in kilograms

In a histogram, data values are placed in groups or "bins" of a certain size, and each group is represented with a bar. The height of the bar tells us the frequency for that group.

For example, the height of the tallest bar is 10, and the bar represents weights from 20 to less than 25 kilograms, so there are 10 dogs whose weights fall in that group. Similarly, there are 3 dogs that weigh anywhere from 25 to less than 30 kilograms.

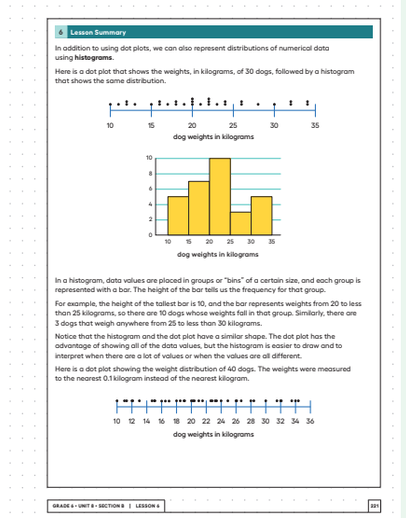
Notice that the histogram and the dot plot have a similar shape. The dot plot has the advantage of showing all of the data values, but the histogram is easier to draw and to interpret when there are a lot of values or when the values are all different.

Here is a dot plot showing the weight distribution of 40 dogs. The weights were measured to the nearest 0.1 kilogram instead of the nearest kilogram.



dog weights in kilograms

Student Workbook



6 Lesson Summary

In addition to using dot plots, we can also represent distributions of numerical data using **histograms.**

Here is a dot plot that shows the weights, in kilograms, of 30 dogs, followed by a histogram that shows the same distribution.

10 15 20 25 30 35

dog weights in kilograms

10 8 6 4 2 0

10 15 20 25 30 35

dog weights in kilograms

In a histogram, data values are placed in groups or "bins" of a certain size, and each group is represented with a bar. The height of the bar tells us the frequency for that group.

For example, the height of the tallest bar is 10, and the bar represents weights from 20 to less than 25 kilograms, so there are 10 dogs whose weights fall in that group. Similarly, there are 3 dogs that weigh anywhere from 25 to less than 30 kilograms.

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Here is a dot plot showing the weight distribution of 40 dogs. The weights were measured to the nearest 0.1 kilogram instead of the nearest kilogram.

10 12 14 16 18 20 22 24 26 28 30 32 34 36

dog weights in kilograms

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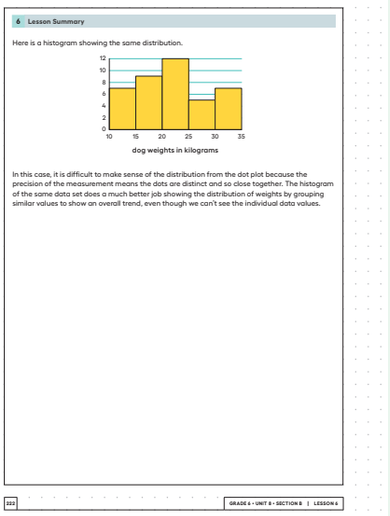
Student Workbook

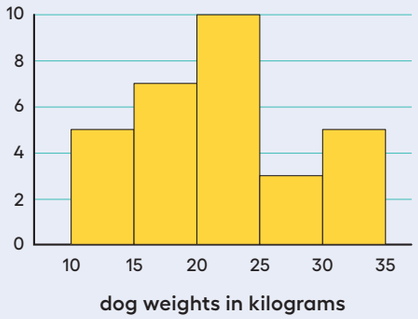


6 Lesson Summary

Here is a histogram showing the same distribution.

In this case, it is difficult to make sense of the distribution from the dot plot because the precision of the measurement means the dots are distinct and so close together. The histogram of the same data set does a much better job showing the distribution of weights by grouping similar values to show an overall trend, even though we can't see the individual data values.

Here is a histogram showing the same distribution.



In this case, it is difficult to make sense of the distribution from the dot plot because the precision of the measurement means the dots are distinct and so close together. The histogram of the same data set does a much better job showing the distribution of weights by grouping similar values to show an overall trend, even though we can't see the individual data values.

Cool-down

Rain in Miami

5 min

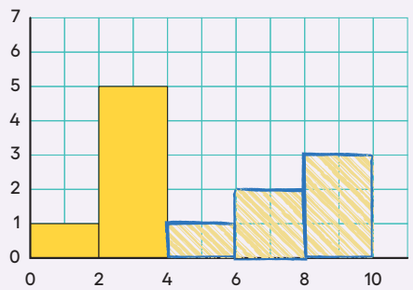
Student Task Statement

Here is the average amount of rainfall, in inches, for each month in Miami, Florida.

month	rainfall (inches)	month	rainfall (inches)
January	1.61	July	6.5
February	2.24	August	8.9
March	2.99	September	9.84
April	3.14	October	6.34
May	5.35	November	3.27
June	9.69	December	2.05

1. Complete the frequency table and use it to make a histogram.

rainfall (inches)	frequency
0–2	1
2–4	5
4–6	1
6–8	2
8–10	3



2. What can you say about the center of this distribution using the histogram?

Sample response: The center of the distribution appears to be between 4 and 6 inches of rain.

Responding To Student Thinking

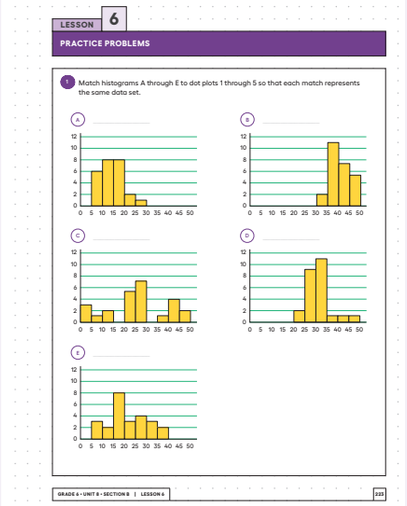
Points to Emphasize
If students struggle with creating a frequency table or histogram, create strategic pairings and allow extra time for students to create the frequency table and histogram in this activity: Unit 8, Lesson 7, Activity 1 Measuring Earthworms

Lesson 6

Practice Problems

4 Problems

Student Workbook


LESSON 6

PRACTICE PROBLEMS

1 Match histograms A through E to dot plots 1 through 5 so that each match represents the same data set.

A B C D E

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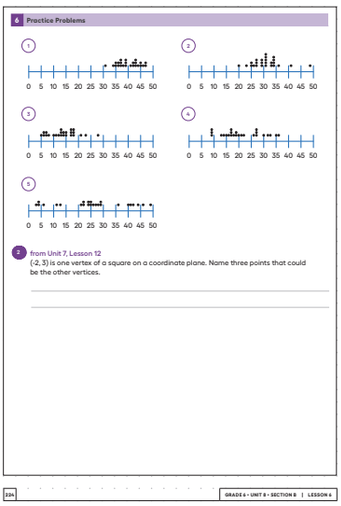
Student Workbook


6 Practice Problems

1 2 3 4 5

2 from Unit 7, Lesson 12
(-2, 3) is one vertex of a square on a coordinate plane. Name three points that could be the other vertices.

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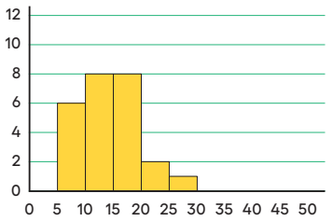
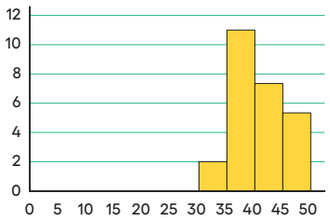
Problem 1

Match histograms A through E to dot plots 1 through 5 so that each match represents the same data set.

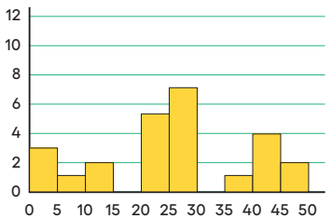
A 3



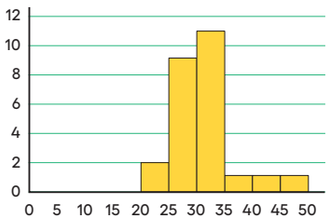
B 1



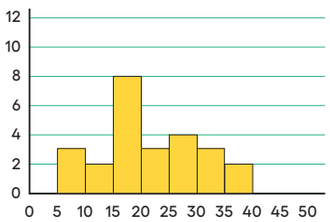
C 5



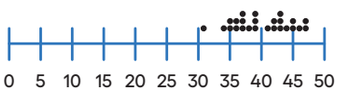
D 2



E 4



1



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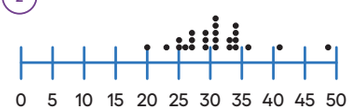

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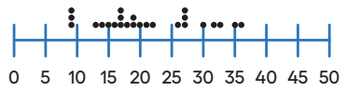

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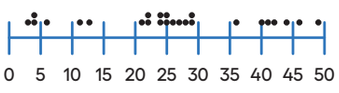


Problem 2

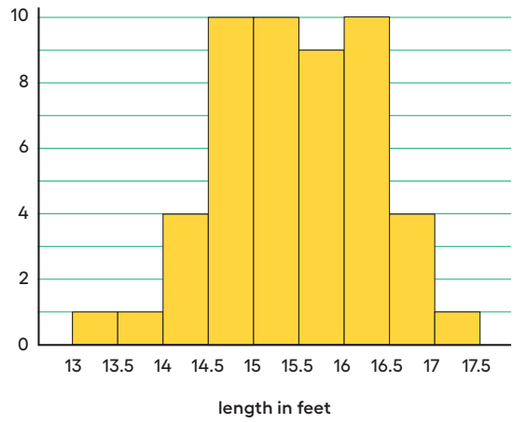
from Unit 7, Lesson 12

(-2, 3) is one vertex of a square on a coordinate plane. Name three points that could be the other vertices.

Sample response: (2, 3), (2, -1), (-2, -1)

Problem 3

Here is a histogram that summarizes the lengths, in feet, of a group of adult female sharks. Select **all** the statements that are true, according to the histogram.



A. A total of 9 sharks were measured.

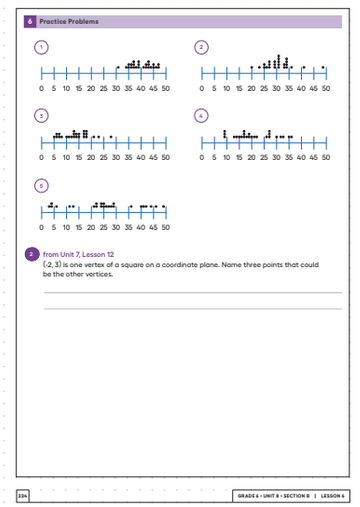
B. A total of 50 sharks were measured.

C. The longest shark that was measured was 10 feet long.

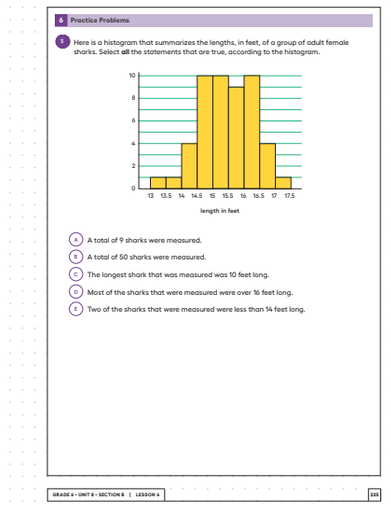
D. Most of the sharks that were measured were over 16 feet long.

E. Two of the sharks that were measured were less than 14 feet long.

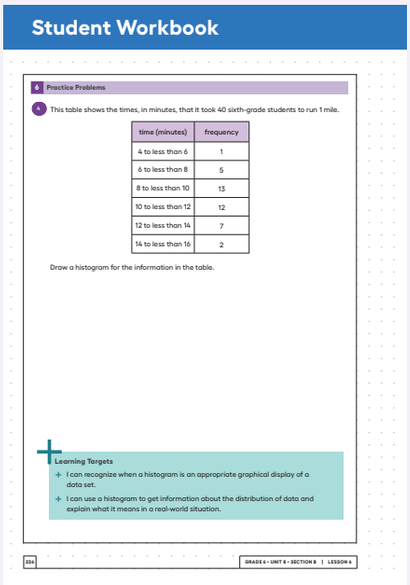
Student Workbook



Student Workbook



Student Workbook



Practice Problems

4. This table shows the times, in minutes, that it took 40 sixth-grade students to run 1 mile.

time (minutes)	frequency
4 to less than 6	1
6 to less than 8	5
8 to less than 10	13
10 to less than 12	12
12 to less than 14	7
14 to less than 16	2

Draw a histogram for the information in the table.

Learning Targets

- I can recognize when a histogram is an appropriate graphical display of a data set.
- I can use a histogram to get information about the distribution of data and explain what it means in a real-world situation.

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Problem 4

This table shows the times, in minutes, that it took 40 sixth-grade students to run 1 mile.

time (minutes)	frequency
4 to less than 6	1
6 to less than 8	5
8 to less than 10	13
10 to less than 12	12
12 to less than 14	7
14 to less than 16	2

Draw a histogram for the information in the table.