## Lesson Overview

This lesson introduces students to the statistical process through the notion of a statistical question, a question that anticipates variability in the response. The lesson helps students develop a sense of the distribution of data, the number of times each possible outcome occurs. The questions are designed to help students think about the overall distribution of data as a story about the data as a whole, rather than thinking of the data as individual elements.

A statistical investigation always begins with a statistical question, one where the responses will have variability.

### Learning Goals

1. Recognize that answers to statistical questions always involve variability;
2. understand the idea of a distribution of a set of data;
3. use range as a rough measure of variability;
4. identify clusters, peaks, and gaps, and recognize common shapes in graphical representations of data (skewed, symmetric, rectangular, mound shaped);
5. identify an outlier informally as a value that is quite different from the other values in the data.

### Prerequisite Knowledge

*Introduction to Data* is the first lesson in a series of lessons that investigates the statistical process. In this lesson, students identify statistical questions and explore distributions of a set of data. Students are introduced to range as a rough measure of variability and informally to the concept of outliers. Prior to working on this activity, students should:

- have knowledge of symmetry as described in the Grade 4 CCSS;
- understand how to plot data on number lines that are appropriately scaled.

## Vocabulary

- **distribution**: describes the number of times each possible outcome appears in a sample or population.
- **symmetric:** describes a shape that has a line of symmetry (the display to the right and left of the line are mirror images of each other).
- **uniform**: describes a distribution in which all of the outcomes are equally likely, rectangular in shape.
- **outlier**: an observation point that is distant or far away from the other values in a set of data.
- **skewed**: the data are clustered at one of the ends of the distribution with values tailing out more narrowly towards the other end. If the tail is on the right the distribution is skewed right; if the tail is to the left, the distribution is skewed left.
- **mound shaped**: describes a graphical display of data that are clustered around a point.
- **range**: the difference between the maximum and minimum values for a set of data.

## Lesson Pacing

This lesson contains multiple parts and can likely be completed in 2-3 class periods, though you may choose to extend, as needed.

## Lesson Materials

- Compatible TI Technologies:

 TI-Nspire CX Handhelds,  TI-Nspire Apps for iPad®,  TI-Nspire Software

- Introduction to Data_Student.pdf
- Introduction to Data_Student.doc
- Introduction to Data.tns
- Introduction to Data_Teacher Notes
- To download the TI-Nspire activity (TNS file) and Student Activity sheet, go to http://education.ti.com/go/buildingconcepts.

## Class Instruction Key

The following question types are included throughout the lesson to assist you in guiding students in their exploration of the concept:

**Class Discussion:** Use these questions to help students communicate their understanding of the lesson. Encourage students to refer to the TNS activity as they explain their reasoning. Have students listen to your instructions. Look for student answers to reflect an understanding of the concept. Listen for opportunities to address understanding or misconceptions in student answers.

**Student Activity:** Have students break into small groups and work together to find answers to the student activity questions. Observe students as they work and guide them in addressing the learning goals of each lesson. Have students record their answers on their student activity sheet. Once students have finished, have groups discuss and/or present their findings. The student activity sheet can also be completed as a larger group activity, depending on the technology available in the classroom.

**Deeper Dive:** These questions are provided to facilitate a deeper understanding and exploration of the content. Encourage students to explain what they are doing and to share their reasoning.

## Mathematical Background

In this TI-Nspire™ lesson students are introduced to the statistical process. According to the Guidelines for Assessment and Instruction in Statistics Education (GAISE) report (Franklin et al, 2005) and to the Common Core State Standards (CCSS) grades 6-8 *Statistics and Probability Progressions*, the statistical process consists of four parts: formulate a question, collect data, analyze data, and interpret results. All of these are enacted in the presence of variability, which distinguishes statistics from mathematics where answers are deterministic and obtained by a purely deductive reasoning process. Statistics is rooted in context, and in contexts, things vary. One focus of this lesson is to introduce students to the notion of a statistical question, a question that anticipates variability in the response. For example, “How old are you?” is not a statistical question because the answer is determined; “How old are the people attending a meeting?” is a statistical question because the response will have to consider some way to account for different ages.

A second focus of the lesson is to develop a sense of the distribution of data, the number of times each possible outcome occurs. The questions are designed to help students think about the overall distribution of data as a story about the data as a whole rather than thinking of the data as individual elements. In the lesson, distributions of data are represented in dot plots, and students become familiar with different shapes: skew, symmetric, mound shaped, and uniform. There is also an informal introduction to outliers. From these representations, new questions arise: “How spread out are the data?” “Where do the data cluster?” “Are there gaps in the data?” The lesson also introduces the notion of range as a rough measure of variability; note that range is a single number, the difference between the maximum value and minimum values, not the interval from the minimum to the maximum.

The data were collected from a variety of sources*, which means that they were collected using different methods, and statements about the distributions of maximum speeds or life spans should be made with caution. Collecting data on the speeds of fish will use very different techniques than those used to estimate the speeds of birds. The speeds might be the maximum speeds for animals going a short distance while others might be speeds for animals going a longer distance. Some of the life spans were from animals in captivity, while others were of animals in the wild. Some of the sources had inconsistent speeds or life spans for a given animal, and in many cases, the numbers are estimates. In all cases, the data represent only some of the recorded observations related to a small sample of animals, and as techniques for tracking the behavior of animals improve, new information is likely to change the current data. Note that no data are given for the maximum speed of different breeds of domestic cats.

* Land animals and birds:

*Natural History* Magazine, March 1974, copyright 1974; The American Museum of Natural History; and James G. Doherty, general curator, The Wildlife Conservation Society; www.thetravelalmanac.com/lists/animals-speed.htm

http://en.wikipedia.org/wiki/Fastest_animals

www.demogr.mpg.de/longevityrecords/0203.htm

www.infoplease.com/ipa/A0004737.html

http://a-z-animals.com/animals/donkey/

Dogs:

www.vetstreet.com/our-pet-experts/meet-eight-of-the-fastest-dogs-on-the-planet http://canidaepetfood.blogspot.com/2012/08/which-dog-breeds-are-fastest.html

http://slimdoggy.com/dog-life-spans/

http://users.pullman.com/lostriver/breeddata.htm

Fish:

http://visual.ly/shark-speed-worlds-fastest-sharkshttp://www.thetravelalmanac.com/lists/fish-speed.htm

www.dfo-mpo.gc.ca/Library/333800.pdf

Sea mammals

www.elasmo-research.org/education/topics/r_haulin'_bass.htm

http://whaleopedia.org/animalfund/harbor-porpoise/

www.enchantedlearning.com/subjects/whales/species/

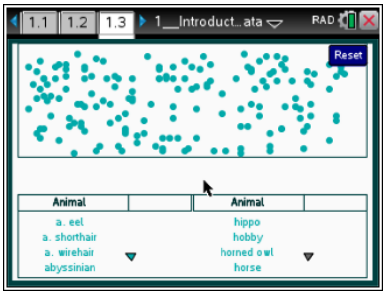
Cats:

www.petcarerx.com/article/the-average-lifespan-of-a-cat-breed-by-breed-chart/1698

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R., (2007). *Guidelines and Assessment for Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework.* Alexandria, VA: American Statistical Association.

## Part 1, Page 1.3

Focus: Students explore and describe distributions of data.




Page 1.3 displays a dot plot in which data about animals is sorted into two categories: maximum recorded speed and record life span.

**Type** selects the category of animal data.

**Attribute** selects the attribute studied.

**Tab Key** selects whether tab chooses the table columns or toggles through the data.

**Animal** orders the table alphabetically.

**Speed/Life Span** orders the table numerically.

Use the arrow keys to scroll through the data in the column

**TI-Nspire Technology Tips**

menu accesses page controls.

tab toggles between columns or between data points.

enter selects and deselects the highlighted data point.

esc deselects all points.

Students can select up to five dots on the dot plot and a list of the animals associated with those dots will be displayed, highlighting the animal and its information in the table below the dot plot.

**Teacher Tip:** Point out that numbers that run along the bottom of the dot plot represent miles per hour if the selected variable is maximum speed or number of years if the selected variable is life span.

Give students time to repeat Part 1 before asking them a focused set of questions. Encourage students to use the TNS activity to explain or demonstrate their reasoning.

The following questions introduce the notion that a statistical investigation always begins with a statistical question, one where the responses account for variability.

**Teacher Tip:** The first problem in the activity contains data about the maximum recorded speeds and lifespans of selected animals from different species. (Note that different sources often report slightly different data, so the figures given should be considered approximate. The methods of collecting the maximum speeds are different for different species, often over different distances.)

### Class Discussion

***Some questions can be answered with an exact response. A statistical question is a question where the answers will vary. Which of the following questions seem to be statistical questions? Explain why.***

a. ***What is the fastest recorded speed for a human?***

b. ***How fast do animals that primarily live on land run?***

c. ***Can land animals travel faster than birds?***

d. ***How much water does a dog drink in a day?***

e. ***How many pets do you have?***

Answer: Questions for a) and e) would not involve any variability. You would just give the exact answer. Questions b, c, and d seem to be statistical questions. For b) you would have to think about how to describe all of the animals as some run fast and some slow; for c) some might travel faster than bird and some might not; and for d) a dog will typically drink a different amount of water on different days, depending on the weather, etc.

**Teacher Tip:** Remind students that each dot in the dot plot represents one animal. Explain that the collection of dots is a "distribution" of data.

***Select* 'Type' *in the tool bar and choose 'all' Choose the attribute 'max speed', maximum speeds in miles per hour.***

- ***Write down two things you wonder about when you look at the distribution of the maximum speeds***.

  Answers will vary. Many students will wonder what animal is associated with the dot at 240 mph. Others might wonder about the maximum speed of a specific animal. Some might wonder if one group of animals runs faster than another.

- ***Are the things you wonder about statistical questions? Why or why not?***

  Answers will vary. The first two examples above are not statistical questions because there is no variability. The third is a statistical question because there would be variability in describing the speed of a group.

- ***Selecting a dot in the plot will show the animal associated with the dot and highlight the animal in the list. Selecting an animal in the list will highlight the associated dot in the plot. Does this help you figure out what you are wondering about? Share your "I wonders" with a classmate.***

  Answers will vary. This linking will help answer the two "I wonder" example questions above.

**Class Discussion (continued)**

- ***How does the maximum speed of an orca compare to the speeds of other animals?***

  Answer: The maximum speed of the orca is 30 mph, which is right in the middle of most of the speeds.

> **Teacher Tip:** Explain to students that an *outlier* is a data value that is far away from the other values in the data set.

- ***What animal has a maximum speed that seems unusual, like an "outlier"? Look up the animal and research how it protects its body when it travels that fast.***

  Answer: The falcon's maximum speed is 242 mph, way faster than any other animal. Their eyes have third eyelids that tear up and clean debris from their eyes when traveling so fast. They also hit the wing of their prey so the impact does not damage their body.

***Because the distribution of maximum speeds has a lot of values at one end and then tails off to the right, it is called a skewed distribution and, in this case, would be called* skewed right *because the tail of the distribution of maximum speeds is located on the right.***

- ***Which species of animals seem to have maximum speeds greater than or equal to 60 mph? Where will these animals be represented in the plot? Explain how you found your answer.***

  Answer: Of the 20 animals whose maximum speed is greater than or equal to 60 mph, 17 are birds, 2 are land animals (Siberian tiger and cheetah), and 1 is a fish (the sailfish). It seems like birds have the fastest maximum speeds of all the animals on the list. The fastest animals are in the tail. Students could find their answers by highlighting the animals in the plot and recording the animals, or they could click on the label *speed* in the lists to order the animals in terms of magnitude of speed, from smallest to largest, then scroll to find the animals with speeds greater than or equal to 60 mph.

- ***How would you describe the typical maximum speeds of all of the animals?***

  Answers will vary. The typical maximum speeds seem to be from about 22 to 48 mph.

- ***Are there any "outliers" in this distribution of maximum speeds? Explain***.

  Answer: The maximum speed of the falcon is twice that of the speed of the next fastest animal, which is another bird, the swift at 120 mph.

## Class Discussion (continued)

***Reset the page. Choose the maximum speeds of land animals.***

- ***You learned about symmetric shapes in earlier grades. Would you say the distribution of the maximum speeds of land animals is relatively symmetric? Why or why not?***

  Answer may vary. Some might consider the distribution almost symmetric around the middle, about 30 mph, with one side kind of like the other except for the cheetah at 75 mph. This might be called “mildly” symmetric.

- ***Callie claims that most of the maximum speeds are between 25 mph and 46 mph. Do you agree with her? Why or why not?***

  Answer: Only nine of the speeds are faster and 15 are slower than those in the interval. There are many more in the interval 24 mph to 46 mph, so Callie is right.

- ***The fastest speed for a human is 27.44 mph during a 100 meter sprint by Usain Bolt. How does his speed compare to the maximum speeds of the land animals?***

  Answers will vary. Bolt’s speed is in the lower third of all of the speeds, a bit faster than the maximum speed of a bull terrier (26 mph) and slightly slower than a husky or a giant schnauzer (28 mph).

***Reset the page. Choose the maximum speeds of land animals, dogs. (Note that the dogs are primarily medium and large dogs.)***

- ***Which dogs are the fastest? The slowest?***

  Answer: The fastest dogs are the greyhound at 45 mph, and the saluki at 43 mph; the slowest are the mastiff at 18 mph and the golden retriever at 19 mph.

- ***How does the maximum speed of a whippet compare to the speeds of the other dogs?***

  Answer: The Whippet at 36 mph is faster than all but two of the dogs.

- ***Would you say maximum speed of the husky is in the bottom half of the speeds? Why or why not?***

  Answer: Yes, because there are 24 dogs, and the husky goes at a speed of 28 mph, which is the ninth lowest speed.

- ***How does the maximum speed of a golden retriever compare to the maximum speeds of the other dogs on the list?***

  Answer: The maximum speed of a golden retriever is about 19 mph, and it is in the lower half of the maximum speeds in the graph, actually the second slowest maximum speed.

### Class Discussion (continued)

***Which of the following statements might be used in describing the distribution of the maximum speeds of the dogs on the list? Explain your reasoning. The distribution of the maximum speeds of dogs***

a. ***has most of the speeds from 18 mph to 26 mph.***
b. ***is mound shaped and fairly symmetric.***
c. ***has maximum speeds from a low of 18 mph to a high of 45 mph.***
d. ***has a group of dogs whose speeds are clustered between 25 mph and 36 mph.***

Answers may vary. b), c) and d) seem to be true. Answer a) is not true, as only about 7 dogs have speeds in that interval.

### Student Activity Questions—Activity 1

1. **Create two statistical questions you think you can answer using the 'all', 'max speed' plot. Share your questions and answers with a classmate. Explain why you think the questions are statistical questions.**

   Answers will vary. Students might wonder how fast most of the animals travel, how the speeds vary across the animals, or what speeds seem to be the most common. Look for questions such as "What is the fastest animal?" which is not a statistical question because there is no variability.

2. **Reset the page and choose the file that has the maximum speeds of land animals, all. Would you agree or disagree with the following statements? Explain your reasoning.**

   a. **The lion is one of the fastest animals on the list.**

      Answer: Yes, at 50 mph, the lion (along with three other animals) is faster than all but four land animals.

   b. **The elephant is one of the slowest land animals.**

      Answer: Not really; an elephant travels 25 mph, the same as six other animals, and 15 animals have slower speeds.

   c. **The distribution of maximum speeds is skewed left.**

      Answer: No, the distribution of the speeds is fairly mound shaped, and there is only one extreme value and that is to the right.

   d. **The maximum speed of the cheetah is much faster than the maximum speeds of all of the other land animals.**

      Answers will vary. The cheetah is the fastest of the land animals, but some might not think that speed is really an outlier. It is fine for students to think about this, and you can indicate that they will get a definition for an outlier in later work. Right now they should just be thinking about how the values relate to the distribution.

**Student Activity Questions—Activity 1 (continued)**

3. **Reset the page. Then select 'birds' and create the graph of the maximum speeds of the birds.**

   a. **Does the distribution of the maximum speeds of the selected birds seem skewed, mound shaped or rectangular? Why or why not?**

      Answer: Without the speed of the peregrine falcon, the distribution might almost be rectangular and not skewed. It is not really piled up at one end with a tail at the other.

   b. **Which of the following would you say describes the typical maximum speed of the birds on the list:**

      1) **speeds from 32 mph (robin) to 90 mph (frigate bird);**

      2) **79 – 80 mph (gyrfalcon, golden eagle, merganser, and albatross) and 60 – 61 mph (trumpeter swan, Canada goose, ostrich and hummingbird);**

      3) **120 mph (swift).**

      Answers may vary: Students should see that 120 mph, although almost halfway between the minimum and maximum is not a typical speed; the stack of speeds at 60 – 61 mph and 79 – 80 mph are pretty different to describe a maximum speed; and the interval from 32 mph to 90 mph covers all but the seven slowest and the five fastest speeds, so the interval might be considered a set of typical speeds.

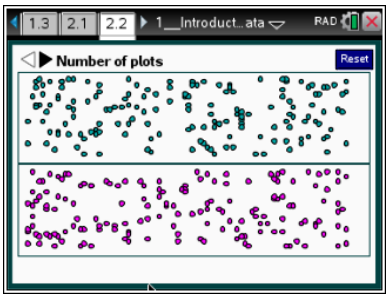
   c. **Name the two birds with the lowest maximum speeds.**

      Answer: The macaw and the amazon parrot at 15 mph.

**Part 2, Page 2.2**

Focus: Students compare different data sets.

On page 2.2 students compare two or four distributions of speeds or life spans depending on the number of plots they choose.




**Number of plots** displays two or four dot plots toggled with the arrow keys. Note that because the same horizontal axis is used for two plots with one directly above the other, it is not correct to display two data sets with different units such as miles per hour on one plot and years of life span on the other.

**TI-Nspire Technology Tips**

menu accesses page controls.

tab toggles between columns or between data points.

## Class Discussion

**Teacher Tip:** The following questions introduce the concept of range as a rough measure of the spread of a distribution of data.

| Have students… | Look for/Listen for… |
|---|---|
| ***Create plots of the maximum speed of 'land animals', 'all' and the maximum speed of 'dogs'.*** | |
| • ***How do the two distributions of maximum speeds compare?*** | Answer: The maximum speeds of the dogs are closer together than the speeds of the land animals, and overall the distribution of the speeds of the dogs is centered slightly to the left with smaller values than the speeds for the land animals. They are both relatively mound shaped and symmetric. |
| • ***The range is the difference between the maximum and minimum values in a distribution and is one way to talk about the spread of the data in the distribution. Compare the ranges of the maximum speeds of the land animals and the dogs.*** | Answer: The range of the maximum speeds of the dogs is $45 - 18 = 27$ mph. The range of the maximum speeds of the land animals is much larger, $75 - 2 = 73$ mph. |
| • ***Does the difference in the ranges make sense? Why or why not?*** | Answer: The difference in ranges makes sense because dogs are one kind of land animal and tend to have similar speeds so the range for their speeds would likely be smaller than the range for all land animals, which would have speeds for all different types of land animals like pigs and lions as well as dogs. |
| • ***How does the typical speed of the dogs seem to compare to the typical speed of the land animals?*** | Answer: The typical maximum speed of the dogs could be anywhere from 25 to 38 mph, and those speeds are just a bit smaller than the typical speeds of all the land animals, which is between 26 mph and 45 mph. The dogs with the fastest maximum speeds are in the middle cluster of speeds for all the land animals. |

### Class Discussion (continued)

- ***Sandee said to look at the most common speed for the dogs, which was at 30 mph and right in the middle. Juan said to look at the distribution of the maximum speeds for the wild land animals; there were two "most common" speeds at 50 mph and at 40 mph. He wanted to know which one you picked, the 50 or the 40 because 40 mph seemed to be in the center and was kind of typical but 50 mph was not. Who do you agree with? Explain why.***

Answers will vary. In statistics, the most common value can be anywhere in a distribution and not really typical. Often there is more than one most common value. For these reasons the most common value is not accepted as being typical. (Such values are formally called modes, but they are not accepted as measures of center for the reasons given.)

### Student Activity Questions—Activity 2

**1. Reset page 2.2. Create a graph showing the maximum speeds of fish.**

**a. Is the distribution of the maximum speeds of fish skewed or relatively symmetric? Explain your thinking.**

Answer: The distribution of the maximum speeds is not skewed and there are too few speeds to really see any shape. If you added three or four new speeds, the shape could be changed a lot which means describing shape is not really appropriate.

**b. Describe any clusters or gaps you see in the distribution of the speeds of fish.**

Answer: Four kinds of fish have very low maximum speeds, the American eel at 2.4 mph, the sturgeon at 5.5 mph, the pike at 3.9 mph, and rainbow trout at 4.5 mph, then there is a gap until the octopus and nurse shark at 25 mph. There is another cluster between 43 and 50 mph, and there is a gap between those fish and the fastest fish, the sailfish, that swims at 68 mph.

**c. What is the range of the speeds of the selected fish?**

Answer: the range is $68 - 2.4 = 65.6$ mph or about 66 mph.

**2. Create a dot plot of the maximum speeds of sea mammals on the same screen as the plot in Question 1.**

**a. How does the distribution of maximum speeds of the sea mammals on the list compare to the maximum speeds of the fish on the list?**

Answer: The distribution of the maximum speed of the seam mammals is below the distribution for fish. Most of the fish are faster than all but one of the seam mammals ( the sei whale at 40 mph). The range of the speeds for the sea mammals (not counting the human), $40 - 5.6 = 34.4$ mph, is much smaller than the range of the speeds of the fish, which is about 65.6 mph. There are so few data points in each of the two graphs it is difficult to make any statement about the shapes. (Note that not all distributions will have a "named shape".)

## Student Activity Questions—Activity 2 (continued)

**b. What seems to be a typical speed for each of the distributions of speeds?**

Answers may vary: A typical maximum speed for the sea mammals might be from about 16 mph to 25 mph, while a typical maximum speed for fish might be about from 35 mph to 40 mph.

## Deeper Dive – Page 1.3

- ***How do you think the distribution of the maximum speeds of wild land animals will compare to the distribution of the maximum speeds for domestic animals? Explain your thinking.***

  Possible answer: The speeds of wild animals will be faster because many of them have to chase their prey in order to eat, while domestic animals usually have no reason to have to run fast.

- ***Display the graph the maximum speeds of the wild land animals and the domestic land animals. Do the distributions of the speeds support your reasoning? Why or why not?***

  Possible answer: The distribution of the maximum speeds of the wild land animals is mound shaped and symmetric. The distribution of the maximum speeds of the few domestic animals has too few data values to say much about the shape. Some wild animals like the porcupine and the beaver have slower maximum speeds than a hamster and farm animals like the chicken goat. Eight wild land animals have a faster speed than the fastest domestic animal. The typical maximum speed of the wild animals is between 30 and 45 mph, while the typical maximum speed of domestic animals is between 25 and 30 mph. The range of the distribution of speeds of the wild land animals is larger than the range of domestic animals, even without counting the cheetah.

- ***Highlight some animals you know are carnivores—eat meat as their regular diet. Describe their speeds.***

  Answers will vary. Answers might include African dog at 44 mph, cheetah at 75 mph, lion at 50 mph, and Siberian tiger at 60 mph.

- ***Which animals seem to have a maximum speed that is faster than most of the animals in the previous question? Explain why this might be the case.***

  Answers will vary. Pronghorn (55 mph), springbok (55 mph), black buck (50 mph), hare (50 mph) red kangaroo (45 mph), wildebeest (50 mph), jackrabbit (44 mph) and gazelle at (43 mph). All of these animals are prey for the carnivores. These animals run faster than all the other carnivores besides the four listed above, and they need to run fast to escape animals such as wolves, coyotes, hyenas.

## Deeper Dive – Page 2.2

- ***Choose four plots on page 2.2. Graph the maximum speeds of dogs, domestic land animals, sea mammals, and fish. How do the four distributions of maximum speeds compare?***

  Answers will vary. Note that this is a good problem for a whole class discussion. The distribution of the maximum speeds of the fish is the most spread out with a range of about 60 mph and gaps between most of the speeds and the smallest and largest speeds. The distributions of the maximum speeds of the dogs and of the sea mammals have about the same ranges, about 35 mph, but the distribution of the speeds of the dogs is overall lower than the distribution of the speeds of the sea mammals. The distribution of the maximum speeds of dogs is mound shaped and symmetric but the other distributions have too few types of animals to really describe the shape. Fish have the fastest typical maximum speeds, between 30 to 42 mph; dogs are next with a group of speeds in the middle between about 28 and 38 mph; then domestic land animals with middle speeds between 25 and 30 mph, and the typical maximum speeds for sea mammals, around 20 to 25 mph, seem to be the slowest.

***Return to page 1.3 and plot the maximum speeds of 'land animals', 'all'.***

- ***Highlight the four animals with the highest maximum speeds.***

  Answer: The cheetah, Siberian tiger, pronghorn, and springbok have the fastest maximum speeds.

- ***Change the attribute to 'life span'. How do these animals compare to the other animals in terms of life spans?***

  Answer. Except for the tiger, they are in the lower half of the maximum number of years land animals typically live.

- ***Identify the five land animals that have the longest recorded lifespans. Then change the attribute to speed. What can you say about the speed of the longest living animals?***

  Answer: The longest living animals are the donkey, the elephant, the hippo, the camel, and the gorilla. Only the camel at 40 mph, has a maximum speed in the top half of the fastest animals on the list. The hippo is in the bottom quarter with a maximum speed of 19 mph.

- ***Write at least two statistical questions you would like to investigate about the typical life span of the different species of the selected animals. Write your questions and the answers using language and ways of describing distributions of data similar to those you used in the lesson's questions.***

  Answers will depend on student questions.

  **Teacher Tip:** You may wish to suggest students look at the situations below if they need help in creating questions.

  - Note that the distribution of the life spans of all animals is skewed right, with most of the life spans between 4-30 years, but the maximum recorded life span of the bowhead whale is 200 years. The next longest recorded life span is the blue whale at 110 years
  - The distribution of the life spans of birds is slightly skewed right, with the Amazon parrot at 110 years, the cockatoo at 80 years and the macaw at 64 years having longer record life spans than the other birds.

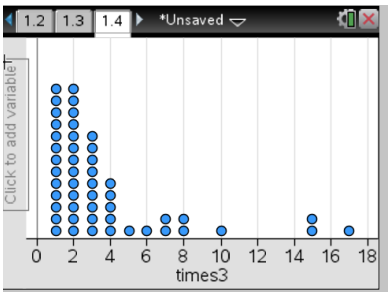
- The distribution of the typical life span of land animals is skewed right. The elephant at 60 years, has a longer record life span than the other humans; the donkey, the camel, and the gorilla all at 50 years have longer record life spans than the other land animals.
- The distribution of the typical life spans of wild animals is slightly skewed right with most animals having maximum recorded life spans from 9 to 25 years but eight animals have maximum recorded life spans from 27 years for the moose to 60 years for the elephant.
- Cats live slightly longer than dogs usually. The range of the maximum number of years cats live is 10 years, from 12 to 22 years; the range of dogs' life spans is almost the same, 9 years, but going from 8 to 17 years.
- The dog with the longest recorded life span is the dachshund at 17 years; almost one third of the dogs live less than the American wirehair cat, which has the shortest life span of the cats, 12 years.
- Aside from the bowhead whale, whose maximum lifespan is 200 years, there seem to be two groups of sea mammals. One group of eight have maximum recorded lifespans from 70 to 110 years, and another group of eight have maximum recorded lifespans from 13 to 50 years, with a gap of 20 years between the two groups. Seven of the eight in the longest living group are whales (exception is the human); the sei, beluga, and minke whales are the longest living in the other group, so overall whales are the longest living group of sea mammals.

## Sample Assessment Items

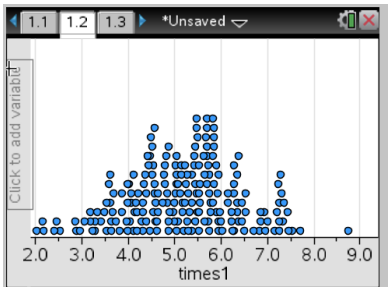
After completing the lesson, students should be able to answer the following types of questions. If students understand the concepts involved in the lesson, they should be able to answer the following questions without using the TNS activity.

1. The four distributions below show the times (number of hours to complete the race) for runners in four different marathon races. Label each as skewed, mound shaped, symmetric, rectangular, or none of these.

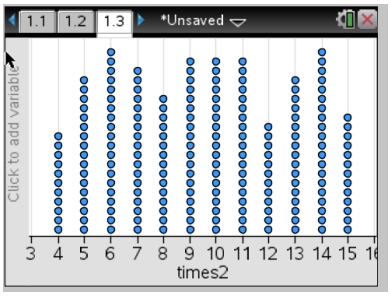
a.



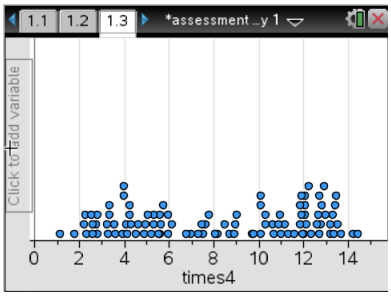

b.




c.

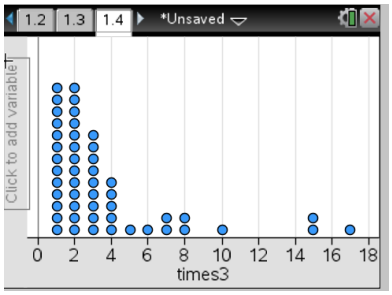



d.




***Answer: a) is skewed right; b) is mound shaped and mildly symmetric; c) is almost rectangular, and d) is mildly symmetric.***

2. The times it took participants to complete a marathon are shown in the graph below. What is the range of the times?




   a. 1 to 17 hours

   b. 16 hours

   c. 17 hours

   d. 1 to 2 hours

   ***Answer: b) 16 hours***

3. Which of the following is a statistical question?

   a. How old are you?

   b. How old are the people attending the meeting?

   c. Who is the oldest person in the room?

   d. What is the difference between the age of the oldest and the youngest person in the room?

   ***Answer: b) How old are the people attending the meeting?***

## Student Activity Solutions

In these activities you will describe and compare distributions of different sets of data. After completing each activity, discuss and/or present your findings to the rest of the class.

**Activity 1 [Page 1.3]**

1. Create two statistical questions you think you can answer using the 'all', 'max speed' plot. Share your questions and answers with a classmate. Explain why you think the questions are statistical questions.

   *Answers will vary. Students might wonder how fast most of the animals travel, how the speeds vary across the animals, or what speeds seem to be the most common. Look for questions such as "What is the fastest animal?" which is not a statistical question because there is no variability.*

2. Reset the page and choose the file that has the maximum speeds of land animals, all. Would you agree or disagree with the following statements? Explain your reasoning**.**

   a. The lion is one of the fastest animals on the list.

      *Answer: Yes, at 50 mph, the lion (along with three other animals) is faster than all but four land animals.*

   b. The elephant is one of the slowest land animals.

      *Answer: Not really; an elephant travels 25 mph, the same as six other animals, and 15 animals have slower speeds.*

   c. The distribution of maximum speeds is skewed left.

      *Answer: No, the distribution of the speeds is fairly mound shaped, and there is only one extreme value and that is to the right.*

   d. The maximum speed of the cheetah is much faster than the maximum speeds of all of the other land animals.

      *Answers will vary. The cheetah is the fastest of the land animals, but some might not think that speed is really an outlier. It is fine for students to think about this, and you can indicate that they will get a definition for an outlier in later work. Right now they should just be thinking about how the values relate to the distribution.*

3. Reset the page. Then select birds and create the graph of the maximum speeds of the birds.

   a. Does the distribution of the maximum speeds of the selected birds seem skewed, moundshaped, or rectangular? Why or why not?

      *Answer: Without the speed of the peregrine falcon, the distribution might almost be rectangular and not skewed. It is not really piled up at one end with a tail at the other.*

b. Which of the following would you say describes the typical maximum speed of the birds on the list:

1) speeds from 32 mph (robin) to 90 mph (frigate bird);

2) 79 – 80 mph (gyrfalcon, golden eagle, merganser, and albatross) and 60 – 61 mph (trumpeter swan, Canada goose, ostrich, and hummingbird);

3) 120 mph (swift).

*Answers may vary: Students should see that 120 mph, although almost halfway between the minimum and maximum is not a typical speed; the stack of speeds at 60 – 61 mph and 79 – 80 mph are pretty different to describe a maximum speed; and the interval from 32 mph to 90 mph covers all but the seven slowest and the five fastest speeds, so the interval might be considered a set of typical speeds.*

c. Name the two birds with the lowest maximum speeds.

*Answer: The macaw and the amazon parrot at 15 mph.*

**Activity 2 [Page 2.2]**

1. Reset page 2.2. Create a graph showing the maximum speeds of fish.

a. Is the distribution of the maximum speeds of fish skewed or relatively symmetric? Explain your thinking.

*Answer: The distribution of the maximum speeds is not skewed and there are too few speeds to really see any shape. If you added three or four new speeds, the shape could be changed a lot which means describing shape is not really appropriate.*

b. Describe any clusters or gaps you see in the distribution of the speeds of fish.

*Answer: Four kinds of fish have very low maximum speeds, the American eel at 2.4 mph, the sturgeon at 5.5 mph, the pike at 3.9 mph, and rainbow trout at 4.5 mph, then there is a gap until the octopus and nurse shark at 25 mph. There is another cluster between 43 and 50 mph, and there is a gap between those fish and the fastest fish, the sailfish, that swims at 68 mph.*

c. What is the range of the speeds of the selected fish?

*Answer: the range is* $68 - 2.4 = 65.6$ *mph or about 66 mph.*

2. Create a dot plot of the maximum speeds of sea mammals on the same screen as the plot in Question 1.

   a. How does the distribution of maximum speeds of the sea mammals on the list compare to the maximum speeds of the fish on the list?

      *Answer: The distributions of the maximum speeds start out not too far apart (at 3.9 and 8 mph), but the fastest maximum speeds of sea mammals (46 mph for the mako shark) are slower than the maximum speeds for the fish (68 mph for the sailfish). The range of the speeds for the sea mammals, $46 - 8 = 38$ mph, is much smaller than the range of the speeds of the fish, which is about 64 mph. The distribution of the maximum speeds for sea mammals might be slightly skewed but there are so few data points in each of the two graphs it is difficult to make any statement. (Note that not all distributions will have a "named shape".)*

   b. What seems to be a typical speed for each of the distributions of speeds?

      *Answers may vary: A typical maximum speed for the sea mammals might be from about 16 mph to 25 mph, while a typical maximum speed for fish might be about from 35 mph to 40 mph.*