Building Concepts: Box Plots

TEACHER NOTES

Lesson Overview

In this TI-Nspire™ lesson, students will interpret data displayed in box plots. In general, box plots are useful when the data set is large or when comparing two or more data sets. Students connect box plots to the five-number summary, helping them understand how to interpret data represented in a box plot.

The three intervals, minimum to LQ, LQ to UQ, and UQ to maximum, contain approximately $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ of the data values, respectively.

Learning Goals

1. Interpret a box plot;
2. understand the relationship between a dot plot and its corresponding box plot;
3. recognize that the sizes of the four intervals determined by the box plot reflect the spread of the data values, but regardless of the width of the interval each interval contains approximately $\frac{1}{4}$ of the data.

Prerequisite Knowledge

Box Plots is the third lesson in a series of lessons that investigates the statistical process. In this lesson, students plot the two extreme values (minimum and maximum), the lower quartile (LQ), upper quartile (UQ), and the median (a five-number summary) on a number line to create a graph called a *box plot*. This lesson builds on the knowledge presented in the previous lesson *Median and Interquartile Range.*
Prior to working on this lesson, students should:

- understand and be able to find the median, quartiles, and interquartile range of a set of data;
- be able to describe a graphical display of data as skewed, mound-shaped, uniform, or symmetric.

Vocabulary

- **median**: the value that separates the upper half of the distribution of a set of data values from the lower half
- **upper quartile**: the value that separates the lower three fourths of the data from the upper quarter of the data.
- **maximum:** the largest value in a data set.
- **box plot:** a representation of a distribution by a rectangle which goes from the lower quartile to the upper quartile, with a segment connecting the minimum value in the data set to the lower quartile and a segment connecting the maximum value in the data set to the upper quartile.
- **lower quartile**: the value that separates the lower quarter of the data from the upper three fourths of the data.
- **interquartile range (IQR)**: the difference between the upper quartile and the lower quartile.
- **minimum:** the smallest value in a data set.

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

- Box Plots_Student.pdf
- Box Plots_Student.doc
- Box Plots.tns
- Box Plots_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 will interpret data displayed in box plots. One of the recommendations for analyzing statistical data is to make use of graphs. Plotting the two extreme values, the lower quartile (LQ), upper quartile (UQ), and the median (a *five-number summary*) on a number line leads to a graph called a *box plot*, a concise way of representing the center, shape, and spread of a data distribution. The three intervals, minimum to LQ, LQ to UQ, and UQ to maximum, contain approximately $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ of the data values, respectively. If there are no repeated data values, then the counts will be more exact, but it is important to note that different methods for computing quartiles can produce slightly different box plots. In general, box plots are useful when the data set is large so a slight variation in what constitutes a quartile will not make an appreciable difference in the analysis. This activity calculates the LQ as the median of those data values that are strictly less than the median of the entire set. Similarly, the UQ is the median of those data values that are strictly greater than the median of the entire set. In this initial activity, the box plots created from the five-number summary do not show points detached from the segments at either end, often called outliers. In activity 8, *Outliers*, students investigate the concept of outliers.

Box plots are particularly well suited for comparing two or more data sets, such as the lengths of mung bean sprouts grown over a period of time in four different conditions or the achievement scores on test items of five different classes.

Students often confuse the length of the line segments at the ends of the box or the width of the box with the density of the data, thinking the “longer the segment, the more data are represented in the segment”. The fact that the area of the box has nothing to do with any characteristic of the data makes box plots difficult to interpret. And just as in Lesson 2, students may think of the interquartile range as an interval rather than as a number representing the width of the interval, i.e., the width of the box.

Part 1, Page 1.3

Focus: Students will connect data displayed in a dot plot with the corresponding box plot and examine the interquartile range and the median of a set of data.

Page 1.3 displays the number of text messages a sample of middle school students send or receive in one day. The data are plotted on a number line.

Median displays the median.

IQR displays the IQR.

Summarize transforms the dot plot into a box plot. Passing the cursor over a segment of the box plot will highlight the data values in that segment. Selecting a segment will keep the values highlighted until you select in a white space on the screen.

Selecting and dragging a dot or dots in the dot plot will move the dots, changing the box plot accordingly.

New Data shows a new distribution of text messages sent or received.

Reset refreshes the page.

TI-Nspire Technology Tips

tab highlights dots in the data set.

enter selects or deselects the dot(s) to be moved using the arrow keys.

esc deselects all segments and dots.

menu accesses page controls.

ctrl del resets the page.

Teacher Tip: Help students make the connection between the median and the interquartile range on the number line and on the box plot. Encourage students to move the dots on the number line so that the median in the box plot changes. Ask questions such as, “How can you adjust the data so that the median is now 80?” Have students work with a partner to explore changing the data in order to get a specific result. Students should all answer one part of the question, then share their answers and discuss the differences. It is important to make the relationship between dot plots and their corresponding box plots explicit: i.e., 1) a box plot will not show gaps and clusters and 2) very different distributions can have the same box plot.

Teacher Tip: This lesson covers concepts that are typically conceptually difficult for students. To develop and support student understanding might take several days, while students engage in exploring page 1.3. Building this understanding is important, however, if students are to retain and use their knowledge of box plots in grades 7 and beyond.

Class Discussion

In the following questions, students will use the median and IQR to develop a box plot as a graphical summary of a distribution of data. The plot displays the results of a survey of the number of text messages sent or received by 12- and 13-year-olds in a day.

Have students…	Look for/Listen for…
• ***Select a dot and explain what it represents.***	Answer: Each dot represents the number of text messages sent or received in a day by a 12- or 13-year-old who took the survey. So, for example, a dot at 40 indicates that one 12- or 13-year-old who took the survey sent or received 40 text messages in a day.
• ***Estimate the median and the interquartile range. Then select Median and IQR to check your estimate.***	Answers will vary. One estimate might be a median of 70 text messages sent/received in a day with an IQR of 70 going from 20 to 90. The median is actually 44, and the IQR is 68.
• ***Describe the distribution of the number of text messages sent or received.***	Answers will vary. The distribution is skewed right with half of the students sending or receiving more than 40 text messages a day. The range was about 138. Typically, about half of the students sent/received anywhere from 20 to 90 messages a day.
• ***Select* Summarize and *describe the new plot.***	Answer: The new plot shows the minimum and maximum number of text messages and has a box around the IQR with segments at either end of the box going to the minimum and maximum number of text messages. A vertical line segment goes through the box at the median.
• ***Approximately how many student responses to the survey are located in the box? Explain your reasoning.***	Answer: At least $\frac{1}{2}$ of the responses are in the box because the IQR contains about $\frac{1}{2}$ of the data, all of the values between the lower quartile and the upper quartile.

Student Activity Questions—Activity 1

1. **Select Summarize. Approximately what fraction of the responses is located on the line segment at the left of the box? At the right of the box? Explain how you found your answers.**

   Answer: Approximately $\frac{1}{4}$ of the responses are located on the segments at the right or the left of the box. The lower and upper ends of the box mark the LQ and UQ, and each of those separates $\frac{1}{4}$ of the data.

2. **Select each of the four sections in the plot. Use the display to check your answers to the question above.**

   Answer: By counting the number of dots in each section, students should see that 9 responses are in the segment between the minimum and the LQ; 18 are in the box between the LQ and UQ; and 9 are in the segment above the UQ. There are 36 responses all together so that means $\frac{1}{4}$ are in the lower segment, $\frac{1}{2}$ in the box, and $\frac{1}{4}$ in the upper segment.

3. **The plot on the upper half of the screen is called a box plot or sometimes a box-and-whisker plot.**

   a. **What values do you need to create a box plot?**

      Answer: You need five values: the minimum, maximum, LQ, UQ, and median.

   b. **Why is the vertical line segment in the box not in the middle of the box?**

      Answer: Because the median is not always in the middle of the interval defining the IQR. The location of the median depends on how the data values are spread on the number line.

   Teacher Tip: This set of questions gives students a chance to investigate the relationship between a box plot and a dot plot.

4. **Suppose some of the survey responses were entered incorrectly.**

   a. **All three numbers represented by the three dots just to the right of 60 should have been entered as 80. Move the dots to the correct position. Does the box plot change? Explain why or why not.**

      Answer: The box plot does not change because the three values are still in the region between the median and the UQ.

   b. **The number of text messages between 100 and 120 should have been between 0 and 20. Move the dots to the correct position. Does the box plot change? Explain why or why not.**

      Answer: The box plot changes because the new median is a bit over 20, the lower quartile is around 19 or 20, and the upper quartile about 83 or 84. Moving values below the median or a quartile changes the order and counts used in finding the median and the quartiles.

Student Activity Questions—Activity 1 (continued)

c. Reset the page and recreate the box plot. One report indicated the median was 60. Identify two points that might have been incorrectly entered and what they should have been to have a median of 60.

Answers will vary. Moving the two points on either side of 40 to 60 will give a median of 60.

Part 2, Page 2.2

Focus: Students will investigate how a box plot can be associated with different shapes in corresponding dot plots.

Page 2.2 displays the number of hours a sample of middle school students spend online in one day. The page functions the same way as page 1.3.

5 Num. Summary identifies the minimum, lower quartile, median, upper quartile, and maximum of the data.

New Data displays a new distribution of hours online.

Student Activity Questions—Activity 2

1. The box plot represents the responses of middle school students to a survey on the number of hours they spend online during a day.

a. What can you see from the dot plot that you cannot see from the box plot?

Answer: There seems to be almost two groups of students because there is a gap between 5 and 6 hours of watching. One group of students is online for 5 or fewer hours and the others for 6 or more hours. The box plot does not show the gaps or the mounds on either side of the gap from 5 to 6.

b. Select 5 Num. Summary in the lower right of the screen. Identify the five-summary points that determine the box plot and the IQR.

Answer: Min = 0 hours; LQ = 3.5 hours; Med = 5 hours; UQ = 7.5 hours; Max = 11 hours. The IQR is 4 hours.

c. The width of the section from the median to the upper quartile is wider than the section from the lower quartile to the median. Does this mean there are more student responses in that section? Why or why not? Select sections of the box plot to verify your answer.

Answer: Selecting sections shows that each section has eight responses to the survey; the width of the box only shows that the eight responses in the section from the median to the UQ were spread out more than the responses in the section from the LQ to the median.

d. What fraction of the student responses is contained in the interval determined by the box?

Answer: $\frac{1}{2}$

Class Discussion

Have students…	Look for/Listen for…
Select the segment to the right of the box.	
• ***Move the points in that upper segment slightly to the right. Which of the five-number summary values did not change? Explain why.***	Answer: The median, LQ, UQ, and minimum did not change because changing the order for the values above the UQ will not change the order for those below the UQ and so those summary numbers remain the same.
• ***Teri claims that if you dragged all the values in the lower segment of the box plot to the right, the only summary number that will change is the maximum. Do you agree with Teri? Why or why not? Use the TNS activity to help your thinking.***	Answer: I disagree with Teri. All the five-number summaries change depending upon how far to the right you drag the points.

Teacher Tip: It is important to make the relationship between dot plots and their corresponding box plots explicit: i.e., 1) a summary as represented in a box plot will not show gaps and clusters and 2) very different distributions can have the same box plot.

Reset the page. Keep the minimum and maximum number of hours the same. Create the following distributions of the number of hours online, and then interpret the corresponding box plot in terms of the number of hours students reported being online.	
• **A skewed distribution**	Answers will vary. One possible answer for a distribution that is skewed right: Min = 0 hours; LQ = 1.5 hours; Med = 3 hours; UQ = 6 hours; and Max = 11 hours. The median is to the far left of the box; the length between the median and UQ is twice as long as the length between the LQ and median; and the segment on the right, 5 hours, is long. The box plot has a very small segment on the left because at least $\frac{1}{4}$ of the students are online for less than 1.5 hours. The typical number of hours to be online for about half of the students varies about 4.5 hours, from 1.5 to 6 hours. $\frac{1}{4}$ of the students are online from 6 to 11 hours.

Class Discussion (continued)

- **A symmetric distribution**

  Answers will vary. One possible answer for Min = 0 hours; LQ 2.5 hours; Med = 6 hours; UQ = 9.5 hours; and Max = 11 hours. The median is 6 hours, right in the center of the box and in the middle of the length between the minimum at 0 and the maximum at 11. The sections on each side have about the same width, which means they have about the same spread among the hours. There is a pretty big spread in the total number of hours online with a range of 11 hours (0 to 11), and about $\frac{1}{2}$ of the students are online from 2.5 to 9.5 hours a day.

- **A uniform distribution**

  Answers will vary. One possible answer for Min = 0 hour;s LQ = 2.5 hours; Med = 5.5 hours; UQ = 8.5 hours; and Max = 11 hours. The students responded they were online for almost all of the whole numbers of hours between 0 and 11. The dots representing the distribution of hours are in a long line with one or two places where they are close together. The box plot could have been the box plot from the symmetric distribution above with median at 5.5 in the middle of the box and of the distance between the minimum of 0 and the maximum of 11.

- **A mound shaped distribution**

  Answers will vary. The number of hours could cluster at a variety of places over the domain. One possible answer for Min = 0 hours; LQ = 5 hours; Med = 6 hours; UQ = 6.5 hours; and Max = 11 hours. The IQR is very small, only 1.5 hours; half of the students are online between 5 and 6.5 hours a day. The segments for the boxes are long with the spread of hours online for those in the top $\frac{1}{4}$ of the data from 6.5 to 11 and for the bottom fourth from 0 to 5 hours.

Part 3, Page 3.2

Part 3 Focus: Students realize that the number of values in any of the four intervals determined by the box plot is $\frac{1}{4}$ (approximately) of all of the values

Page 3.2 shows the four sections of a box plot as they are displayed in a corresponding dot plot.

Select any two of the rectangles and the rectangles will exchange their location in the box plot.

TI-Nspire Technology Tips

tab highlights dots in a rectangle.
enter selects a rectangle.
esc deselects all rectangles.
ctrl del resets the page.

Class Discussion

Select any two sections of the plot on the bottom will exchange the sections.

- ***How many data points are in each section of the box plot?***

  Answer: Six.

- ***Exchange the two middle sections. Did the IQR change? Why or why not? Did the median change?***

  Answer: The IQR did not change because the LQ and UQ did not change. The median changed from 8 to 7 because six equivalent values switched places from 8 to 6.

Student Activity Questions—Activity 3

1. For each of the following, sketch the plot and state the IQR.

a. Move the sections to create a plot with the largest IQR you can.

Answer: The largest possible IQR is 9.

b. Create a plot that has the shortest possible segment on the left end.

Answer: Any plot that has the section with 6 responses all the same value as the last section on the left will have the shortest line segment on the left.

c. Create a plot that is skewed left.

Answer: Arrange the sections so the base of each section goes from 6 responses to 3 responses to 2 responses to 1 response.

d. Density is the amount of a quantity per unit of area. Create a plot that has the maximum density between the LQ and the UQ.

Answer: The maximum density will be the one with the smallest IQR, which will occur when the section with 1 response all the same and the section with 2 different responses are in the IQR, for an IQR = 3.

Part 4, Page 4.2–4.3

Focus: Students will continue to examine data graphed on a box plot.

Page 4.2 displays box plots of the number of text messages sent or received by a sample of middle school girls and boys. The lengths of the intervals determined by the five critical points can be changed by dragging the dots.

Page 4.3 displays box plots of the number of text messages from randomly generated samples of boys and girls. The plots on page 4.3 are not interactive.

New Data displays a new distribution of hours online.

TI-Nspire Technology Tips

tab selects the dots on page 4.2 that can be moved.

esc deselects all segments and dots.

menu accesses page controls.

enter generates new data.

ctrl del resets the page.

Teacher Tip: Interpreting box plots can be difficult for students. Questions related to pages 4.2 and 4.3 might take yet another class period.

Class Discussion

Use the dots to change the summary points to make each of the following statements true. Sketch your results.

- ***Half of the girls send or receive more text messages than $\frac{1}{4}$ of the boys.***

  Answers will vary: Any two box plots where the median number of messages girls send/receive is greater than or equal to the upper quartile of the number of messages boys send/receive will satisfy the condition. Sample answer below.

Class Discussion (continued)

- ***Typically, $\frac{1}{2}$ of the boys sent or received from 120 to 160 text messages, while $\frac{1}{2}$ of the girls sent or received 80 to 160 text messages.***

  Answers will vary depending on the maximum and minimum values for each. Sample plot below.

Student Activity Questions—Activity 4

1. The two box plots show the girls' and boys' responses to the survey about the number of text messages sent or received per day.

a. Describe the key differences between the responses of the boys and of the girls.

Answer: Some boys do not send or receive any, while girls send/receive at least 40 text messages. All of the girls send or receive more messages than $\frac{1}{4}$ of the boys. At least $\frac{1}{2}$ of the girls send/receive more messages than all the boys. The spread of the girls is more than the spread of the messages the boys send/receive.

b. What would you choose as the typical number of text messages that girls in the survey send or receive per day? Boys?

Answers may vary. Using the medians, girls tend to send or receive 140 text messages a day, while the boys send or receive 60 messages a day. Using the difference between the LQs and the UQs, at least $\frac{1}{2}$ of the girls send or receive between about 60 and 160 text messages per day, while at least $\frac{1}{2}$ of the boys send or receive between about 40 to 100 text messages per day.

c. Describe the difference in the distributions of the number of text messages boys and girls send or receive per day.

Answers will vary. The difference between the medians: $140 - 60 = 80$
a difference of 80 text messages per day. The middle 50 percent of the girls has a spread of $160 - 60 = 100$ (IQR). The middle 50 percent of the boys has a spread of $100 - 40 = 60$ (IQR), which is a smaller spread than the girls. (The description should include a comparison of both center and spread.)

Deeper Dive – Page 1.3

Select* New Data *to produce the number of text messages sent/received reported by another sample of students.

- ***Describe the box plot and the distribution of the number of text messages.***

  Answers will vary. For example, students in one random sample sent or received anywhere from 25 to about 90 text messages. About $\frac{1}{4}$ of them sent/received less than about 70, and $\frac{1}{2}$ of them sent/received between 70 and 80 messages a day.

- ***Exchange answers to part a) with a partner. Do you agree or disagree with each other? Explain your reasoning.***

  Answers will vary.

Deeper Dive – Page 2.2

Drag one or more points to create each of the following. (Remind students that all highlighted points will move when one point is dragged. To deselect highlighted points select in a white space.)

- ***A distribution that is skewed left with Min = 1; Max = 12; and UQ = 11. Sketch your box plot.***

  Answers will vary. One possible answer:

- ***LQ = 6; Med = 7; and UQ = 7.5. Sketch your box plot***.

  Answers will vary. One possible answer:

- ***Which of the two distributions of the number of hours online has more variability in the responses within the middle 50% of the students? Explain your reasoning.***

  Answers will vary. For the two examples, the first has more variability because the IQR is larger.

Deeper Dive – Page 4.3

On page 4.3 the data shows the results from a large survey of middle school students about the number of hours they send or receive text messages.

- ***Looking at the two box plots, do you agree that girls send more text messages than boys? Explain your reasoning.***

  Answers will vary: At least $\frac{3}{4}$ of the girls send more messages than $\frac{1}{2}$ of the boys might be an argument in favor of the girls. At least one boy sends more messages than any of the girls and the top quarter of the boys send more than the top quarter of the girls could be an argument in favor of the boys.

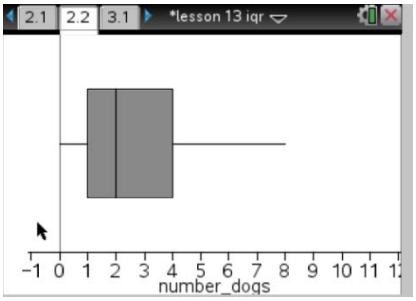
- ***Use* New Data *to find two box plots where boys send or receive more text messages than girls. Make a sketch of the plots and be ready to defend your thinking to a partner.***

  Answers will vary. Sample answers below.

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 plot below shows the results of a survey of households about the number of dogs in the household. Identify the following statements as true or false. Explain your reasoning in each case.



   a. The maximum number of dogs in any house is 8.

   b. At least $\frac{1}{2}$ of the houses have 2 or more dogs.

   c. Every house in the survey had at least 1 dog.

   d. Half of the houses surveyed have between 1 and 4 dogs.

   Answer:

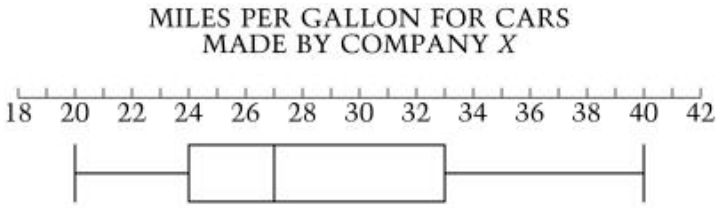
   a. True, because the segment at the top goes to 8.

   b. True, because 2 is the median.

   c. False, because the lower segment starts at 0 so at least one household does not have a dog as a pet.

   d. True, because the interval between the LQ and UQ goes from 1 to 4 and that marks off the middle half of the data.

2.



According to the box-and-whisker plot above, $\frac{3}{4}$ of the cars made by Company *X* got fewer than how many miles per gallon?

NAEP, Grade 12, 2005

a. 20

b. 24

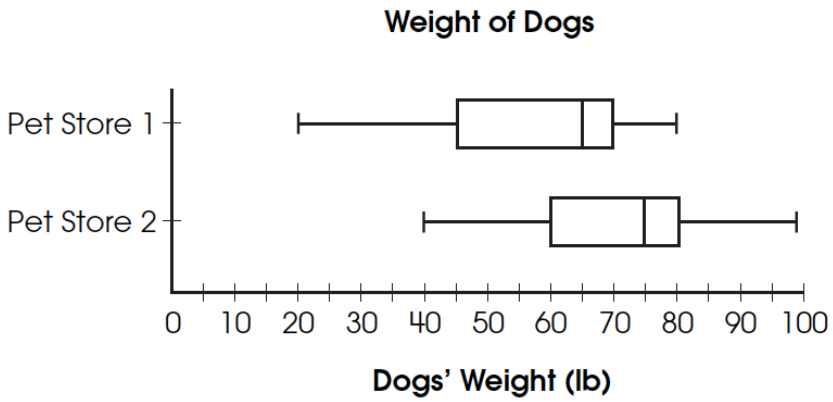
c. 27

d. 33

e. 40

Answer: d) 33

3. The box-and-whisker plots show the distribution of weight among dogs in two different pet stores.



How much greater is the median weight of the dogs in Pet Store 2 than in Pet Store 1?

Ohio Achievement Test, 2005 Grade 8

a. 5

b. 10

c. 15

d. 20

Answer: b) 10

Student Activity Solutions

In these activities you will work together to create a box plot and determine the interquartile range and the median of the set of data. After completing each activity, discuss and/or present your findings to the rest of the class.

Activity 1 [Page 1.3]

1. Select **Summarize**. Approximately what fraction of the responses is located on the line segment at the left of the box? At the right of the box? Explain how you found your answers.

   Answer: Approximately $\frac{1}{4}$ of the responses are located on the segments at the right or the left of the box. The lower and upper ends of the box mark the LQ and UQ, and each of those separates $\frac{1}{4}$ of the data.

2. Select each of the four sections in the plot. Use the display to check your answers to the question above.

   Answer: By counting the number of dots in each section, students should see that 9 responses are in the segment between the minimum and the LQ; 18 are in the box between the LQ and UQ; and 9 are in the segment above the UQ. There are 36 responses all together so that means $\frac{1}{4}$ are in the lower segment, $\frac{1}{2}$ in the box, and $\frac{1}{4}$ in the upper segment.

3. The plot on the upper half of the screen is called a box plot or sometimes a box-and-whisker plot.

   a. What values do you need to create a box plot?

      Answer: You need five values: the minimum, maximum, LQ, UQ, and median.

   b. Why is the vertical line segment in the box not in the middle of the box?

      Answer: Because the median is not always in the middle of the interval defining the IQR. The location of the median depends on the data values are spread on the number line.

4. Suppose some of the survey responses were entered incorrectly.

   a. All three numbers represented by the three dots just to the right of 60 should have been entered as 80. Move the dots to the correct position. Does the box plot change? Explain why or why not.

      Answer: The box plot does not change because the three values are still in the region between the median and the UQ.

   b. The number of text messages between 100 and 120 should have been between 0 and 20. Move the dots to the correct position. Does the box plot change? Explain why or why not.

      Answer: The box plot changes because the new median is a bit over 20, the lower quartile is around 19 or 20, and the upper quartile about 83 or 84. Moving values below the median or a quartile changes the order and counts used in finding the median and the quartiles.

c. Reset the page and recreate the box plot. One report indicated the median was 60. Identify two points that might have been incorrectly entered and what they should have been to have a median of 60.

Answers will vary. Moving the two points on either side of 40 to 60 will give a median of 60.

Activity 2 [Page 2.2]

1. The box plot represents the responses of middle school students to a survey on the number of hours they spend online during a day.

   a. What can you see from the dot plot that you cannot see from the box plot?

   Answer: There seems to be almost two groups of students because there is a gap between 5 and 6 hours of watching. One group of students is online for 5 or fewer hours and the others for 6 or more hours. The box plot does not show the gaps or the mounds on either side of the gap from 5 to 6.

   b. Select **5 Num. Summary** in the lower right of the screen. Identify the five-summary points that determine the box plot and the IQR.

   Answer: Min = 0 hours; LQ = 3.5 hours; Med = 5 hours; UQ = 7.5 hours; Max = 11 hours. The IQR is 4 hours.

   c. The width of the section from the median to the upper quartile is wider than the section from the lower quartile to the median. Does this mean there are more student responses in that section? Why or why not? Select sections of the box plot to verify your answer.

   Answer: Selecting sections shows that each section has eight responses to the survey; the width of the box only shows that the eight responses were spread out more than the responses in the section from the LQ to the median.

   d. What fraction of the student responses is contained in the interval determined by the box?

   Answer: $\frac{1}{2}$

Activity 3 [Page 3.2]

1. For each of the following, sketch the plot and state the IQR.

   a. Move the sections to create a plot with the largest IQR you can.

   Answer: The largest possible IQR is 9, from 5 to 14.

   b. Create a plot that has the shortest possible segment on the left end.

   Answer: Any plot that has the section with 6 responses all the same value as the last section on the left will have the shortest line segment on the left.

   c. Create a plot that is skewed left.

   Answer: Arrange the sections so the base of each section goes from 6 responses, to 3 responses to 2 responses to 1 response.

d. Density is the amount of a quantity per unit of area. Create a plot that has the maximum density between the LQ and the UQ.

Answer: The maximum density will be the one with the smallest IQR, which will occur when the section with 1 response all the same and the section with 2 different responses are in the IQR, for an IQR = 3.

Activity 4 [Page 4.2-4.3]

1. The two box plots show the girls' and boys' responses to the survey about the number of text messages sent or received per day.

   a. Describe the key differences between the responses of the boys and of the girls.

   Answer: Some boys do not send or receive any, while girls send/receive at least 40 text messages. All of the girls send or receive more messages than $\frac{1}{4}$ of the boys. At least $\frac{1}{2}$ of the girls send/receive more messages than all the boys. The spread of the girls is more than the spread of the messages the boys send/receive.

   b. What would you choose as the typical number of text messages that girls in the survey send or receive per day? Boys?

   Answers may vary. Using the medians, $\frac{1}{2}$ of the boys send or receive 60 or more messages a day, while $\frac{1}{2}$ of the girls send or receive 140 or more text messages a day. Using the difference between the LQs and the UQs, at least $\frac{1}{2}$ of the girls send or receive between about 60 and 160 text messages per day, while at least $\frac{1}{2}$ of the boys send or receive between 40 to 100 per day.

   c. What would you say is the typical difference in the number of text messages boys and girls send or receive per day?

   Answers will vary. One answer might use the difference between the medians: $140 - 60 =$ a difference of 80 text messages per day. Others might use the quartiles to find a range for the differences: at least 40 to at most 160 for over half of the students.