Explore/Explain 1: Man In The Box

Purpose: Explore measures of central tendency and range using numerical and graphical representations. Technology tools will be used to generate numerical and graphical representations.

Descriptor: Participants will measure attributes to gather data. They will create stem and leaf plots using web-based tools to represent the center and the spread of this data. Participants will use a web-based tool to create a box and whisker plot to explore in greater detail the shape and the spread of the data. Participants will also use hand-held graphing technology to create box and whisker plots. They will gather additional data to explore how such changes impact measures of central tendency.

Duration: 2.25 hours

Mathematics TEKS Objectives:

6.10A	The student uses statistical representations to analyze data. The student is expected to select and use an appropriate representation for presenting and displaying different graphical representations of the same data including line plot, line graph, bar graph, and stem and leaf plot.
6.10B	The student uses statistical representations to analyze data. The student is expected to identify mean (using concrete objects and pictorial models), median, mode, and range of a set of data.
6.10D	The student uses statistical representations to analyze data. The student is expected to solve problems by collecting, organizing, displaying, and interpreting data.
7.11A	The student understands that the way a set of data is displayed influences its interpretation. The student is expected to select and use an appropriate representation for presenting and displaying relationships among collected data, including line plot, line graph, bar graph, stem and leaf plot, circle graph, and Venn diagrams, and justify the selection.
7.11B	The student understands that the way a set of data is displayed influences its interpretation. The student is expected to make inferences and convincing arguments based on analysis of given or collected data.
7.12A	The student uses measures of central tendency and range to describe a set of data. The student is expected to describe a set of data using mean, median, mode, and range.
7.12B	The student uses measures of central tendency and range to describe a set of data. The student is expected to choose among mean, median, mode, or range to describe a set of data and justify the choice for a particular situation.
8.12A	The student uses statistical procedures to describe data. The student is expected to select the appropriate measure of central tendency or range to describe a set of data and justify the choice for a particular situation.
8.12C	The student uses statistical procedures to describe data. The student is expected to select and use an appropriate representation for presenting and displaying

relationships among collected data, including line plots, line graphs, stem and leaf plots, circle graphs, bar graphs, box and whisker plots, histograms, and Venn diagrams, with and without the use of technology.

6.11A, 7.13A, 8.14A The student applies Grade 6/7/8 mathematics to solve problems connected to everyday experiences, investigations in other disciplines, and activities in and outside of school. The student is expected to identify and apply mathematics to everyday experiences, to activities in and outside of school, with other disciplines, and with other mathematical topics.

6.11D, 7.13D, 8.14D The student applies Grade 6/7/8 mathematics to solve problems connected to everyday experiences, investigations in other disciplines, and activities in and outside of school. The student is expected to select tools such as real objects, manipulatives, paper/pencil, and technology or techniques such as mental math, estimation, and number sense to solve problems.

6.12A, 7.14A, 8.15A The student communicates about Grade 6/7/8 mathematics through informal and mathematical language, representations, and models. The student is expected to communicate mathematical ideas using language, efficient tools, appropriate units, and graphical, numerical, physical, or algebraic mathematical models.

6.12B, 7.14B, 8.15B The student communicates about Grade 6/7/8 mathematics through informal and mathematical language, representations, and models. The student is expected to evaluate the effectiveness of different representations to communicate ideas.

6.13A, 7.15A, 8.16A The student uses logical reasoning to make conjectures and verify conclusions. The student is expected to make conjectures from patterns or sets of examples and nonexamples.

6.13B, 7.15B, 8.16B The student uses logical reasoning to make conjectures and verify conclusions. The student is expected to validate his/her conclusions using mathematical properties and relationships.

Technology Applications TEKS Objectives:

(1)(B) The student demonstrates knowledge and appropriate use of hardware components, software programs, and their connections. The student is expected to compare, contrast, and appropriately use the various input, processing, output, and primary/secondary storage devices.

(1)(C) The student demonstrates knowledge and appropriate use of hardware components, software programs, and their connections. The student is expected to demonstrate the ability to select and use software for a defined task according to quality, appropriateness, effectiveness, and efficiency.

(6)(A) The student evaluates the acquired electronic information. The student is expected to determine and employ methods to evaluate the electronic information for accuracy and validity.

(7)(H) The student uses appropriate computer-based productivity tools to create and modify solutions to problems. The student is expected to use interactive virtual environments, appropriate to level, such as virtual reality or simulations.

TAKS Objectives:

- Objective 5: Probability and Statistics
- Objective 6: Mathematical Processes and Tools

Technology:

- Internet websites:
  http://www.shodor.org/interactivate/activities/stemleaf/index.html
  http://nlvm.usu.edu/en/nav/frames_asid_200_g_3_t_5.html?open=instructions
- Hand-held graphing technology

Materials:

Advanced Preparation: Prepared signs - "minimum", "maximum", "upper quartile/Q3", "lower quartile/Q1", and "median" (available on CD); Height Number Line (available on CD); Transparencies or PowerPoint**– The Foot Question 1, 2, and 3; Sticky Dot; Box and Whisker Plot**; **Box and Whisker Participant Page, Venn Diagram.** Transparencies of **Group Recording Sheet –** each group will need a transparency of ½ page. The presenter may wish to bookmark the two websites for easy access.

Presenter Materials: Computer with internet access and data projection device or access to a computer lab, graphing calculator with presentation capabilities.

Per group: Centimeter cubes, **Group Recording transparency** (1/2 sheet), transparency marker**, s**ticky dots in two colors

Per participant: Measuring tape, TI-73 graphing calculator, ruler, **Stem and Leaf – Computer Participant Page**, **Box and Whisker Participant Page**, **Box and Whisker Plot – Computer Participant Pages**, **Intentional Use of Data Activity Sheet**, **Technology Tutorials binder**

Per pair of participants: Venn Diagram Participant Page

Leader Notes:

Due to the number of topics present in this lesson, several Explore/Explain cycles occur. As each new topic is introduced, participants explore the topic. The Explain cycle then occurs. This is repeated several times throughout the lesson.

Introductory Activity – Stem and Leaf Plot

This part of the lesson is designed for the entire group of participants. Encourage participants to interact with each other. Ideally, each participant or pair of participants will have access to a computer for this activity. The presenter(s) should move around the room facilitating the activity. Use the ***Facilitation Questions*** *to guide and redirect participants, as needed.*

1. **What is the average number of centimeters that are added to a person's height when standing on his tiptoes? Who do you predict would gain the most centimeters**

and why do you think this is so? Display **The Foot Question Transparency 1** or PowerPoint slide 1. In groups of 4-5, have participants discuss this question and their reasoning. Allow several participants to share their reasoning. One answer may be "females will gain more height because they tend to be more flexible than males, therefore their feet can flex further." Another answer may be "taller people may gain more height because they tend to have larger feet which will give them added height when standing on their tiptoes."

2. **What data would need to be collected to answer this question?** Flat-footed and tiptoe heights will need to be measured. As a group, determine how the each of these will be measured. Will you measure with or without shoes? When standing on tiptoes, will participants lean against the wall? How accurately should we measure? (Measure to the nearest centimeter.)

3. **Allow participants several minutes to measure their flat-footed and tiptoe heights.** Each group should record their results on the **Group Recording Sheet** transparency. Groups should keep this transparency at their tables at this time.

4. **Each participant should count out the number of centimeter cubes that represents the number of centimeters of height that were added when he/she stood on their tiptoes**. For example, if a participant's flat-footed height was 162 centimeters and tiptoe height was 167 centimeters, the participant will need 5 cubes (167-162=5).

5. **How could the cubes be used to find the mean number of centimeters that were added to participants' heights?** In groups of 4-5, have participants trade centimeter cubes until everyone has the same number of cubes. If this is not possible because the cubes are discrete, ask the students to describe the mean as between "___ and ___, nearer to ____ because we have more students with this number than the other." Use the Facilitation Questions below to debrief this further.

Facilitation Questions

- On average, how many centimeters of height were added to a participant when he/she stood on tiptoes?
  Answers may vary.
- Was the amount of height increase the same for everyone?
  Probably not.
- Which participants gained the most height when standing on his/her tiptoes? Why do you think this is so?
  Participants with larger feet may have gained the most height.
- Which participants gained the least height when standing on his/her tiptoes? Why do you think this is so?
  Participants with smaller feet may have gained the least height. Also, heels on shoes may have impacted the flat-footed height so there is not as great a gain on the tiptoe height.

6. **What impact will the tiptoe heights have on the mean, median, mode, and range of the flat-footed heights?** Display **The Foot Question Transparency 2** or PowerPoint slide 2. Allow groups several minutes to discuss this question. As groups are discussing this question, collect the **Group Recording transparencies**. Then have several groups share their predictions and reasoning on the impact of the tiptoe heights on the mean, median, mode, and range of the flat-footed heights.

7. **In order to find the measures of central tendency and the range for the flat-footed heights, participants will create a stem and leaf plot on the computer.** Distribute the **Stem and Leaf – Computer Participant Page** to each participant. The participants should open the web page to access the Stem and Leaf Plotter.

8. Randomly call out one of the flat-footed heights from the transparencies. Participants should enter this height into the applet and press Update Plot. **What did the applet do to the number to begin creating the stem and leaf plot?**

9. Using the transparencies, continue to call out the flat-footed heights of the remaining participants in a random order.

10. Participants should complete the activity page - **Stem and Leaf – Computer Participant Page**. As participants are completing the page, monitor and ask the following Facilitation Questions if necessary. Make sure participants have copied down their stem and leaf plot onto their activity page before moving to the next step.

Facilitation Questions

- Describe some stems and leaves that would be unreasonable for this situation. Why are they unreasonable?
  Stems that would be unreasonable include values above 20 (unless there are very tall participants.) Stems less than 14 would also be unreasonable unless there is a very short participant.
- Identify the minimum value of the data. Where is this found on the stem-and-leaf plot?
  The minimum value is the first data value listed on the stem-and-leaf plot.
- Identify the maximum value of the data. Where is this found on the stem-and-leaf plot?
  The maximum value is the last data value listed on the stem-and-leaf plot.
- Is the data symmetrical?
  Answers will depend on data collected. If it is not symmetrical, lead a discussion on why it is not.
- Is there any clustering in the stem and leaf plot? (Data that is grouped closely together). If so, what does this clustering imply?
  If clustering occurs, it means that several participants had similar heights.

11. **The applet created what is called a stem and leaf plot. What is the purpose of a stem and leaf plot?** *It provides the data in a least-to-greatest format. You can identify the mode, minimum, maximum, range, and median fairly easily on a stem-and-leaf plot. You can also identify extreme values.*

12. **The stem and leaf plotter found the mean, median, and mode of the data. What does the mode height signify?** The mode height is the most common height. **How could we show the mode height by using the actual participants?** One possible answer is that the participants could line up to identify the most common height.

13. **The applet also found the median of the flat-footed heights. What is the meaning of the median?** The median is the height of the person in the center of the group when the group is lined up from shortest to tallest.

14. **How could we demonstrate finding the median with a sample of participants?** Ask one person from each group to come to the front of the room. Have participants devise a strategy to find the median height. Use a strategy suggested by the participants. One suggestion is for the participants to line up from shortest to tallest. Then take one participant off both ends until only one remains.

15. **Could there be more than one participant in the middle? Explain how this could happen.** When there is an even number of participants, there will be two participants left in the middle. **How will you determine the median height if there are an even number of participants?** Find the average of the two heights in the center.

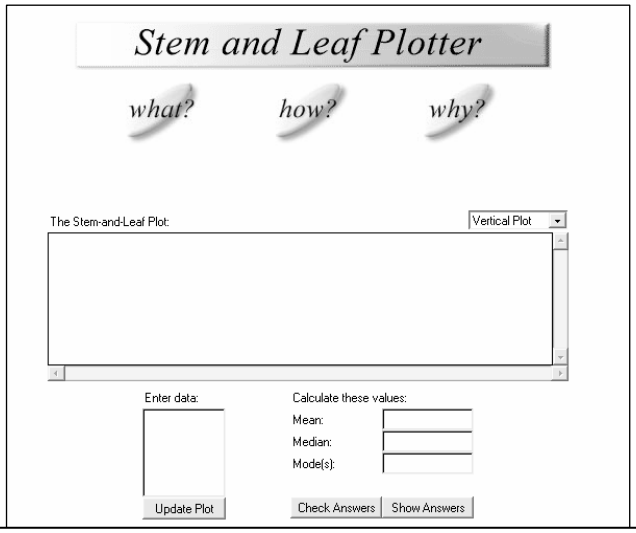
16. **The applet did not calculate the range of heights. How could we find the range of the heights?** The range of the heights is the difference between the height of the tallest person and the shortest person.

17. **How could we physically show the range?** Have the tallest and shortest participants stand next to each other. The difference in their heights is the range. **If another group performed this same experiment and found a larger range, what could you conclude about that group?** The difference in heights between the tallest and shortest person was greater.

18. **Why was technology used to introduce the concept of a stem and leaf plot?** It provided a way for students to learn about the concept by making hypotheses and verifying their predictions. The technology shows students how to create a stem and leaf plot. By middle school, students know how to order whole numbers from least to greatest. The technology can do this quickly so that more time can be spent analyzing the data.

Stem and Leaf - Computer Activity Page

1. Open the Stem and Leaf Plotter on the computer.
   http://www.shodor.org/interactivate/activities/stemleaf/index.html
2. Enter the data as the presenter calls it out in the box titled: "Enter data." Then select "Update Plot."
3. Sketch your stem and leaf plot below.



Stem and Leaf Plotter retrieved 10/29/05 from
http://www.shodor.org/interactivate/activities/stemleaf/index.html

4. Estimate the values of the mean, median, and mode(s). Enter your estimates in the boxes. Then select "Check answers."

5. The stems are the values found to the left of the vertical line on the stem and leaf plot. Where do these values come from?
   These values represent the hundreds and tens place of the heights.

6. The leaves are the values found to the right of the vertical line on the stem and leaf plot. Where do these values come from?
   These values represent the ones place of the heights.

7. If you turned the stem and leaf plot horizontally, what type of graph would it resemble? Use the drop down menu to select Horizontal Plot. Does this verify your prediction?
   The graph would resemble a histogram since the stems represent ranges of numbers.

Box and Whisker Plots – By Hand

This part of the lesson is designed to show the participants how to transform the collected data into a box and whisker plot. The presenter should mount the Height Number Line on the wall where it will be easily visible. Use the ***Facilitation Questions*** *to guide and redirect participants, as needed.*

Box and whisker plots can be created several ways. One way is to find the lower and upper quartiles with the median removed from the data set. Another method includes the median as a member of both the upper and lower 50% of the data in order to find the upper and lower quartiles. This difference will only be apparent if there are an odd number of values in the data set. The method used below does not include the median when finding the upper and lower quartiles. This method of not including the median to calculate upper and lower quartiles is the one the state of Texas will use when assessing students.

1. In order to answer the question that was posed earlier, "What impact will the tiptoe heights have on the mean, median, mode, and range of the flat-footed heights?" a box and whisker plot will be created. This will be done by hand first with the flat-footed heights in order to understand how box and whisker plots are created. The plot will then be created on the computer.

2. A box and whisker plot organizes the data in a very unique way. One thing a box and whisker plot will show is where the middle 50% of the heights falls. **What strategy can be used to find the heights that represent the middle 50% of the class?** Display the PowerPoint slide 3 or **Box and Whisker Plot Transparency**. In groups of 4-5, allow participants time to discuss strategies for accomplishing this task.

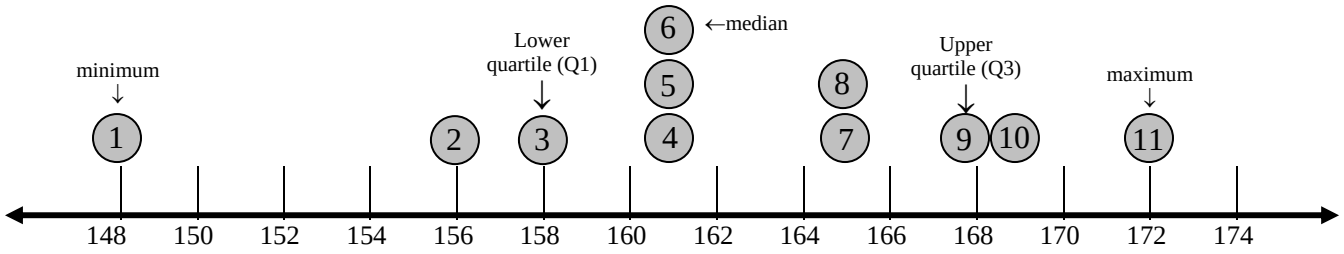
3. **Display PowerPoint slide 4 or Sticky Dot Transparency**. As participants are discussing the questions from the Box and Whisker Plot transparency, each participant will place two sticky dots on the number line to designate his flat-footed height and tiptoe height. One color will be used for each. Sticky dots placed above the number line will be for the tiptoe height. Sticky dots placed below the number line will be for the flat-footed heights.

4. **How do the sticky dots compare for the two data sets**? *The sticky dots for the tiptoe heights are shifted to the right of the sticky dots for the flat-footed heights. The clustering and spread should be fairly similar for the two data sets.*

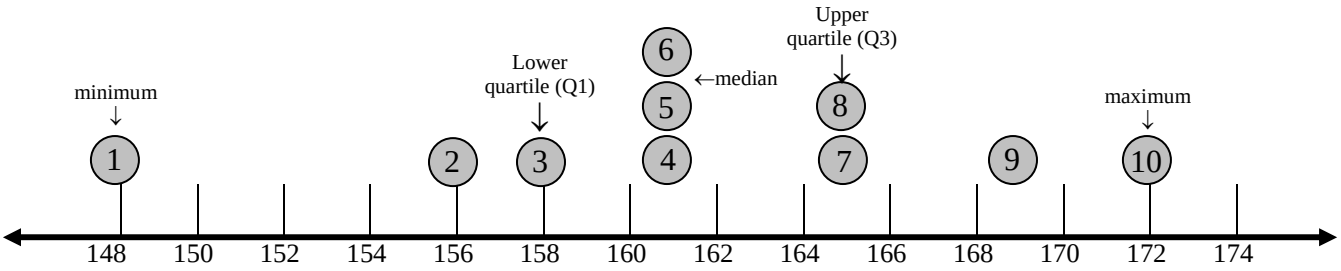
5. **Now that we see where all the heights fall, how could we find the flat-footed heights of the participants that represent the middle 50% of the participants?**
   The median height divides the group into two equal sections. Divide each of those sections into two equal groups and take the "half" closest to the center.

6. **Using a strategy suggested by the participants, ask two participants to help find the sticky dots that represent the middle 50% of the class.** As the participants identify the lower quartile, median, and upper quartile, mark these values with the prepared signs. See the samples below. Use the Facilitation Questions to debrief participants.

Example with an odd number of sticky dots: (Note: the dots have been numbered for illustrative purposes only.) Since there are 11 sticky dots, the 6th dot would be the median. Therefore, 5 dots are to the left of the median and 5 dots are to the right of the median. The 3rd dot is the median of the left half of the data (Q1) and the 9th dot is the median of the right half of the data (Q3).



Example with an even number of sticky dots: (Note: the dots have been numbered for illustrative purposes only.) Since there are 10 sticky dots, the median would fall between the 5th and 6th dots. Therefore, 5 dots are to the left of the median and 5 dots are to the right of the median. The 3rd dot is the median of the left half of the data (Q1) and the 8th dot is the median of the right half of the data (Q3).



Facilitation Questions

- Is there the same number of sticky dots in each group? Which groups have the same number of sticky dots?
  There should be the same number of sticky dots in each group. About one-fourth of all the dots should be in each group.
- Can you tell the height of the tallest person and shortest person from the sticky dots? If so, what are they and how do you know?
  The sticky dot that is farthest to the right represents the tallest person and the sticky dot that is farthest to the left represents the shortest person.
- Explain how to find the range from the sticky dots.
  Find the difference between the tallest height and shortest height.
- Can you tell the mean height from the sticky dots?
  Just by looking at the sticky dots, you cannot tell the mean. You would have to perform some calculations.
- Can you tell the mode height from the sticky dots?
  You will probably be able to see this based on the placement of the sticky dots.
- Can you tell the median height from the sticky dots? If so, what is it and how do you know?
  Yes, the median height is the height that falls in the center of the spread of data.

7. **Lead the participants through the creation of the box and whisker plot on a number line.** (Refer to the Box and Whisker How-To Presenter Page for directions on how to create a Box and Whisker Plot.) Participants will create the box and whisker plot on the **Box and Whisker Plot Participant Page**, part I, at the same time as the presenter creates the plot on a transparency of the same page. After completion of this task, each participant will mark where his/her height falls on his/her box and whisker plot.

8. **What information does the length of the box and whiskers provide?**
   They show the spread of data. The longer they are, the more spread out the data is.

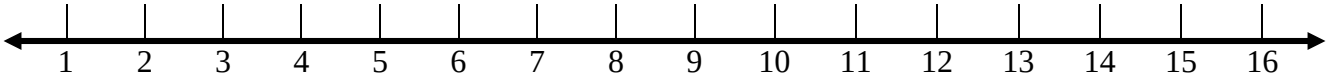
9. **If the range were smaller, predict the impact that would have on the box and whisker plot.**
   It would be more compact on the number line.

10. **Why are the box sections not equal in length? (If they are equal in length, have participants discuss if they will always be equal in length.)**
    The box sections are usually not equal in length because they represent the spread of the data. Even though they have the same amount of data in each section, the spread may differ.

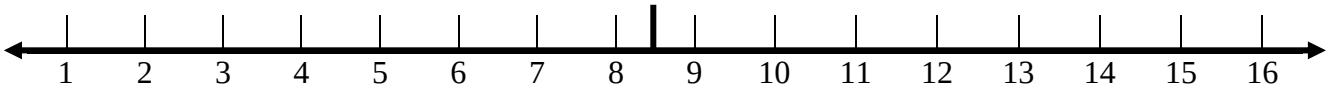
Presenter Page: How To Create a Box and Whisker Plot

The steps and examples listed below are for the following data set:
1, 3, 5, 5, 5, 8, 9, 10, 12, 15, 15, 16

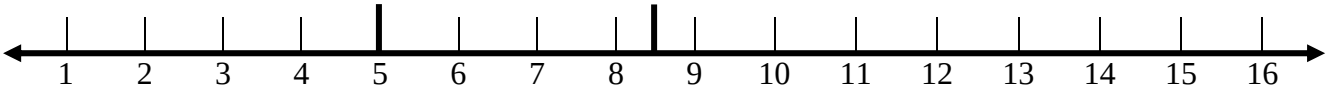
1. Draw a horizontal number line that represents the range of your data.



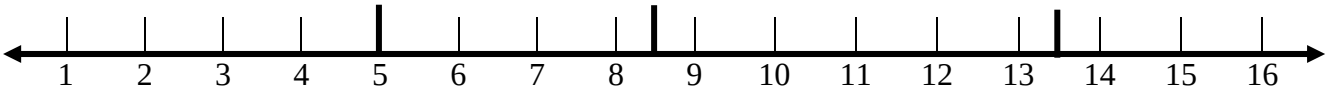
2. Draw a vertical line at the median of your data.



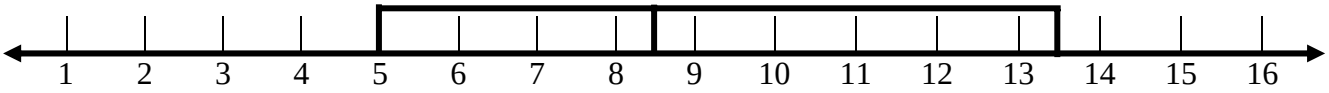
3. Draw a vertical line at the lower quartile of your data (the lower ¼ of the data).



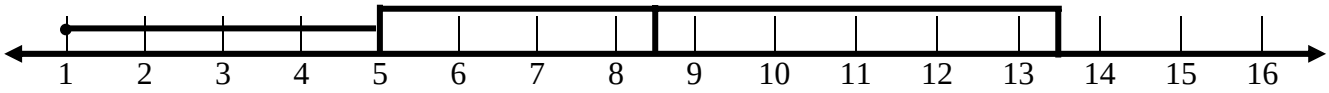
4. Draw a vertical line at the upper quartile of your data (the upper ¼ of the data).



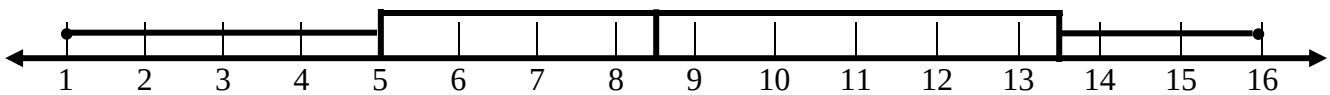
5. Connect the three vertical lines to create a “box”.



6. Mark a point at the minimum value of your data. Connect this point with a horizontal line to the lower quartile. This creates your left whisker.



7. Mark a point at the maximum value of your data. Connect this point with a horizontal line to the upper quartile. This creates your right whisker.



Box and Whisker Plot - Computer

This part of the lesson is designed to show the participants how to create a box and whisker plot on the computer. Ideally, each participant or pair of participants will have access to a computer for this activity. ***This applet includes the median as a member of both the upper and lower 50% of the data, so results may differ from the box and whisker plot created by hand if there are an odd number of data values.*** *Use the* ***Facilitation Questions*** *to guide and redirect participants, as needed.*

1. Distribute the **Box and Whisker Plot – Computer Participant Pages**. Participants will complete this activity individually or with a partner. The presenter should be moving around the room guiding participants where needed.

Facilitation Questions

- What value(s) could be added to "stretch out" the box? Explain why.
  Increasing or decreasing values within the box will stretch it out.
- Predict how the plot would change if each height was increased by 10 centimeters.
  The plot would shift 10 units to the right on the number line.

2. **Why did you use the data from your stem and leaf plot to create the box and whisker plot?** *To practice reading a stem and leaf plot.*

3. **Why did we create a box and whisker plot by hand before using the technology?**
   Answers may include: box and whisker plots are more complicated to figure out what is happening with the data – the creation of a box and whisker plot is not as apparent as a stem and leaf plot.

4. **What are some benefits to using this website to create a box and whisker plot?**
   Answers may include: automatic creation of number line, calculation of first and third quartiles, calculation of mean and median, automatically sorts data, etc. The applet was large and easy to read.

5. **How does the technology allow you to manipulate the data?**
   We can continue entering new values and the plot will automatically adjust. By hand, it would take much longer to adjust the plot.

6. **How does the technology support us as we ask questions?**
   We can verify our predictions using the technology.

7. **Are there any limitations of using this website to create a box and whisker plot?**
   You can only have one box and whisker plot displayed at a time.

8. **What types of information does a box and whisker plot show that a stem and leaf plot does not show?**
   A box and whisker plot identifies median and lower/upper quartiles. It also shows the spread of the data.

9. **What types of information does a stem and leaf plot show that a box and whisker plot does not show?**
   A stem and leaf plot shows individual data values.

Box and Whisker Plot – Computer
Participant Page 1

1. Open the Virtual Manipulatives website. **http://nlvm.usu.edu/en/nav/vlibrary.html**
   - Click on Data Analysis and Probability Grades 6-8.
   - Click on Box Plot.
   - Click on Clear in the lower left corner to clear the list of data.
2. Using your Stem and Leaf Activity Page, enter the shortest height first.
3. Using your Stem and Leaf Activity Page, enter the tallest height second.
4. Continue by entering heights from the lower 50% of the data. Why does the "box" shift as more values are entered? ***The box shifts to the right as larger values are entered. The box contains the approximate middle 50% of the data.***
5. Predict what will happen to the graph as the remainders of the class heights are entered. ***The box will continue to shift to the right.***
6. Verify your prediction by entering the upper 50% of the data. More cells will automatically be created as you need them. Was your prediction correct? _____
7. What is the minimum value of data? _____ Where do you see this on the graph? ***The minimum value is the point at the far left of the box and whisker plot.***
8. What is the maximum value of data? _____Where do you see this on the graph? ***The maximum value is the point at the far right of the box and whisker plot.***
9. About 75% of the class is taller than what height? ***Q1***
10. About 50% of the class is shorter than what height? ***The median height***
11. What is the median height? _____Where do you see this on the graph? ***The line in the middle of the box***

Box and Whisker Plot – Computer Activity Page 2

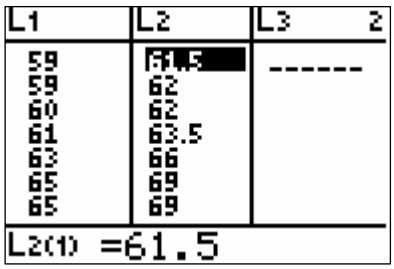
12. Add some data that will change the minimum value. What data did you add? Why did this data change the minimum value? ***Any value less than the minimum will change the minimum value. There is a new number that is less than all the other numbers.***
13. Add some data that will change the maximum value. What data did you add? Why did this data change the maximum value? ***Any value greater than the maximum will change the maximum value. There is a new number that is greater than all the other numbers.***
14. Add some data that will shift the median to the left. What data did you add? Why did this data shift the median to the left? ***Any value less than the median will shift the median to the left. It shifted to the left because there is now more data on the left than on the right. The median has to shift to adjust and become the center of the data set.***
15. Add some data that will shift the median to the right. What data did you add? Why did this data shift the median to the right? ***Any value greater than the median will shift the median to the right. It shifted to the right because there is now more data on the right than on the left. The median has to shift to adjust and become the center of the data set.***
16. Add some data that will cause the whiskers to be equal in length. What data did you add? Why did this data create whiskers of equal length? ***Data should be added so the ranges of the whiskers are equal in length.***
17. Add some data that will cause the box sections to be equal in length. What data did you add? Why did this data create box sections of equal length? ***Data should be added so the range from the lower quartile to the median is equal to the range from the median to the upper quartile.***
18. Add some data that will cause the right whisker to be about twice the length of the left whisker. What data did you add? Why did this happen? ***The range of the right whisker should be twice the range of the left whisker.***
19. Generate a list of new data that will allow the average to fall in the whiskers. Why did the average fall in the whiskers? ***Example: 1, 2, 3, 4, and 20. The average can be found in the whiskers when extreme values of the data exist.***

Box and Whisker Plot – Graphing Calculator

This part of the lesson is designed to show the participants how to create a box and whisker plot on the graphing calculator. Participants should be seated in groups of 4-5 and each participant will need a graphing calculator.

1. Display **The Foot Question Transparency 3** or PowerPoint slide 5**. How do you think the box and whisker plot will change if we graph the tiptoe heights rather than the flat-footed heights?** Allow participants several minutes to discuss this step. Ask 2-3 groups to share their predictions.

2. **Since the applet only allowed one box and whisker plot at a time, the data will be entered into the graphing calculator.** This will allow participants to see the impact on the statistical measures and on the box and whisker plot. Lead participants through entering the flat-footed and tiptoe heights of the participants in L_1 and L_2. Participants will enter the flat-footed heights into L_1 and the tiptoe heights into L_2. Display the Group Recording transparencies one at a time for participants to enter the data. Participants may wish to refer to the **Creating a Box and Whisker Plot Tech Tutorial**.



3. **Participants will verify the mean, median, mode, and range** they previously found for the flat-footed heights on their Box and Whisker Plot Participant Page. Participants may wish to use the One-Variable Statistics Tech Tutorial. **They will also find these values for the tiptoe heights**.

4. **How do the measures of central tendency and range compare for List 1 and List 2**?
The mean and median should be larger. The range may or may not be the same.

5. **How can we verify the mean we found using the centimeter cubes?**
Subtract the mean of the flat-footed heights from the mean of the tiptoe heights.

6. **Create two box and whisker plots on the graphing calculator**, referring to the Creating a Box and Whisker Plot Tech Tutorial as necessary. Participants will sketch the tiptoe plot on the Box and Whisker Plot Participant Page above the flat-footed graph.

7. **Use the Trace feature of the calculators to verify the key values** (the minimum, first quartile, median, third quartile, maximum) on their Box and Whisker Plot Participant Page.

8. Debrief this part of the lesson with the following Facilitation Questions.

Facilitation Questions

- What were your predictions on the comparison of the tiptoe height box and whisker plot to the flat-footed box and whisker plot? Were your predictions accurate?
  Answers may vary.
- What were your predictions on the comparison of the statistical measures for the tiptoe heights and the flat-footed heights? Were your predictions accurate?
  Answers may vary.
- How are the two plots similar?
  The spread and shape of the plots should be similar.
- How are the two plots different?
  The answer will depend on the data collected.
- Is the spread of the data the same for the two plots? How do you know?
  The answer will depend on the data collected.
- What types of information does the box and whisker plot show?
  Spread of data, median, minimum, maximum values.
- What types of information does a box and whisker plot NOT show?
  Mean, individual data values, mode.
- What type of information can be used to create a box and whisker plot?
  Numerical since it is a plot of data on a number line.
- Name some benefits to using a box and whisker plot.
  Seeing the spread of the data is the primary benefit to using a box and whisker plot.
- What are the relative advantages and disadvantages of using a graphing calculator to solve this problem?
  Responses may vary. Answers may include: automatic sorting of data, calculation of median and quartiles very quickly with only a few keystrokes, ability to look at more than one box and whisker plot at a time, etc. However, the small screen is difficult to see and the axes cannot be labeled.
- What are the relative advantages and disadvantages of using web-based tools to solve this problem?
  Like the graphing calculator, data analysis can be done with a few keystrokes and clicks. The graphs can be copied and pasted into other computer documents. A disadvantage would be lack of Internet access at times. Computers are not as portable as graphing calculators.

Summary

Pairs of participants will create a Venn diagram to summarize what they have learned about stem and leaf plots and box and whisker plots.

1. Display the **Venn Diagram Transparency** or PowerPoint slide 6. Distribute the **Venn Diagram Participant Page** to each pair of participants. Without talking, one person will write something they have learned about stem and leaf plots and box and whisker plots into the Venn Diagram. This can address a mathematical or a technological aspect. The second person will add to the Venn diagram. The participants will continue to complete their two Venn diagrams in this manner.

2. **In small groups of 3-4, participants should share their Venn diagrams**. They may continue to add to their Venn diagrams during this final discussion.

3. Distribute the **Intentional Use of Data Activity Sheet** to each participant.

4. Prompt the participants to work in pairs to identify those TEKS that received greatest emphasis during this activity. Participants should refer to the Mathematics TEKS and the Technology Applications TEKS. *The Leader Notes contain a comprehensive list of the TEKS addressed in this phase of the professional development.*

5. **How does the technology that you used enhance the teaching of those TEKS?** Responses may vary. However, participants should note that using technology enables them to explore a mathematical concept to a much deeper level. Technology makes rich mathematics accessible to a variety of learning styles.

6. Prompt the participants to also identify two key questions that were emphasized during this activity. Participants should identify one key question for mathematics and one key question for technology. Allow four minutes for discussion. Debrief with the Facilitation Questions below.

Facilitation Questions

- Which mathematical TEKS formed the primary focus of this activity? *6.10A, 7.12A, 8.12C*
- What additional math TEKS supported the primary TEKS? *6.10B, 6.10D, 7.11B*
- What Technology Applications TEKS are addressed during this activity? *(1)(B), (1)(C), (6)(A), (7)(H)*
- How do these TEKS translate into guiding questions to facilitate student exploration of the content? *Answers may vary.*
- How do your questions reflect the depth and complexity of the TEKS? *Answers may vary.*
- How do your questions support the use of technology? *Answers may vary.*

7. As a whole group, identify the level(s) of rigor (based on Bloom's taxonomy) addressed, the data sources, and the setting used during this Explore/Explain cycle. Allow three minutes for discussion.

Facilitation Questions

- What attributes of the activity support the level of rigor that you identified? *Answers may include synthesis – when participants generated data to cause changes in the box and whisker plot.*

8. As a whole group, discuss how this activity could be bridged to the classroom. Are there pieces of the activity that could be used with students? What extensions could be made to the activity? *Scatterplots could easily be created to compare the flat-footed heights with the tiptoe heights.*

9. **Discuss how this activity might be implemented in other settings**. Participants should complete the Setting section on their Intentional Use of Data sheet. How could the activity be implemented in these settings? Allow five minutes for discussion. Use the Facilitation Questions below.

Facilitation Questions

- How would this activity change if we had access to one computer or one graphing calculator per participant? *If each participant had their own computer, less discussion would have occurred between participants. The discussion is an important component of the learning.*
- How would this activity change if we had access to one computer or one graphing calculator for the entire group of participants? *The teacher could model the activity using a presentation calculator and computer. However, this does not allow for participants to manipulate the data individually and explore the concepts.*
- How would this activity change if we had used only graphing calculators instead of computer-based applications? *The stem and leaf plot can not be created on the graphing calculator.*
- How would this activity change if we had used only computer-based applications instead of graphing calculators? *The comparison of the box and whisker plots cannot happen using the applet.*
- How might we have made additional use of available technologies during this activity? *Other statistical programs could be used to create the graphs. Participants could have entered their heights into the presenter's calculator. The calculators could then be linked to share the data.*
- Why was technology withheld during the beginning box and whisker part of this activity? *Box and whisker plots are not as easy to understand as stem and leaf plots. Participants need to develop an understanding of how box and whisker plots are created before moving to the technology.*

10. Prompt the participants to set aside the completed **Intentional Use of Data Activity Sheet** for later discussion. These completed activity sheets will be used during the Elaborate phase as prompts for generating attributes of judicious users of technology.

Explore/Explain 1 - Intentional Use of Data

TEKS	Math	*6.10A, 6.10B, 6.10D, 7.11A, 7.11B, 7.12A, 7.12B, 8.12A, 8.12C, 6.11A, 7.13A, 8.14A, 6.11D, 7.13D, 8.14D, 6.12A, 7.14A, 8.15A, 6.12B, 7.14B, 8.15B, 6.13A, 7.15B, 8.16B*	
	Tech Apps	*(1)(B), (1)(C), (6)(A), (7)(H)*	
Question(s) to Pose to Students	Math	*How do you distinguish between when to create a stem and leaf plot and when to create a box and whisker plot?*	
	Tech Apps	*Why is it important to know how to create statistical representations with technology?*	
Cognitive Rigor		Knowledge	✓
		Understanding	✓
		Application	✓
		Analysis	✓
		Evaluation	✓
		Creation	✓
Data Source(s)		Real-Time	*Actual measurements of flat-footed and tiptoe heights were collected.*
		Archival	*The teacher could give the students data that has already been collected.*
		Categorical	*Categorical data can't be used to create stem and leaf plots and box and whisker plots.*
		Numerical	*The data collected was numerical.*
Setting		Computer Lab	*Would work, but not as much communication would occur between participants if each person had his own computer.*
		Mini-Lab	*This is the ideal setting.*
		One Computer	*Students can't discover and explore on their own.*
		Graphing Calculator	*Stem and leaf plots can't be created on graphing calculator.*
		Measurement Based Data	*The activity could be done only with measurement based data, but the technology allows it to be done quicker.*
Bridge to the Classroom		*The stem and leaf activity and box and whisker plot activity can easily be taken to the classroom. The activity could be extended to include scatterplots. In addition, a different question could be asked such as, "Do all people gain the same percentage to their height when standing on their tiptoes?"*	

The Foot Question – Transparency 1

What is the average number of centimeters that are added to a person's height when standing on his tiptoes? Who do you predict would gain the most centimeters and why do you think this is so?

The Foot Question – Transparency 2

How do the measures of the mean, median, mode and range of the tiptoe heights compare to the flat-footed heights?

The Foot Question – Transparency 3

How do the measures of the mean, median, mode and range of the tiptoe heights compare to the flat-footed heights?

How will the box and whisker plots compare for the flat-footed heights and tiptoe heights?

Sticky Dots – Transparency

Place an orange dot above the number line to represent your tiptoe height.

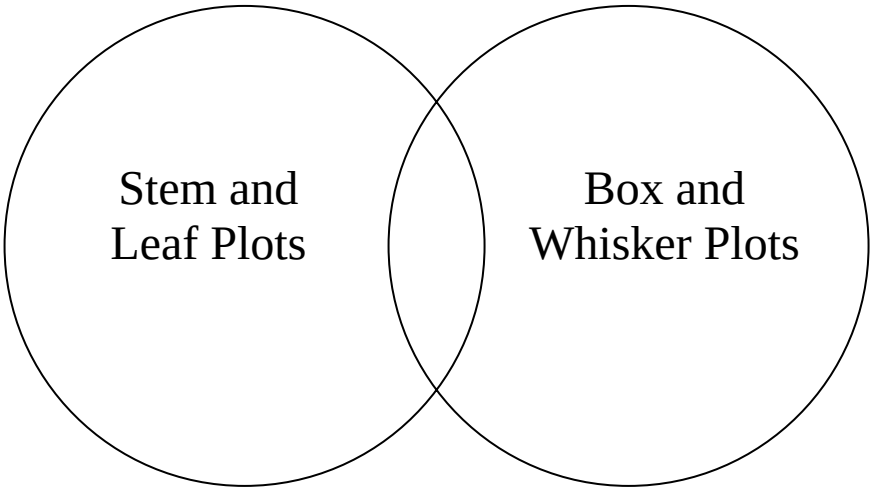
Place a blue dot below the number line to represent your flat-footed height.

Box and Whisker Plot – Transparency

What strategy can you use to find the heights that represent the middle 50% of the participants?

Venn Diagram – Transparency

Without talking, take turns filling in the Venn Diagram. Write what you have learned about stem and leaf plots and box and whisker plots. Address both mathematical and technological aspects.



Group Recording Sheet - Transparency

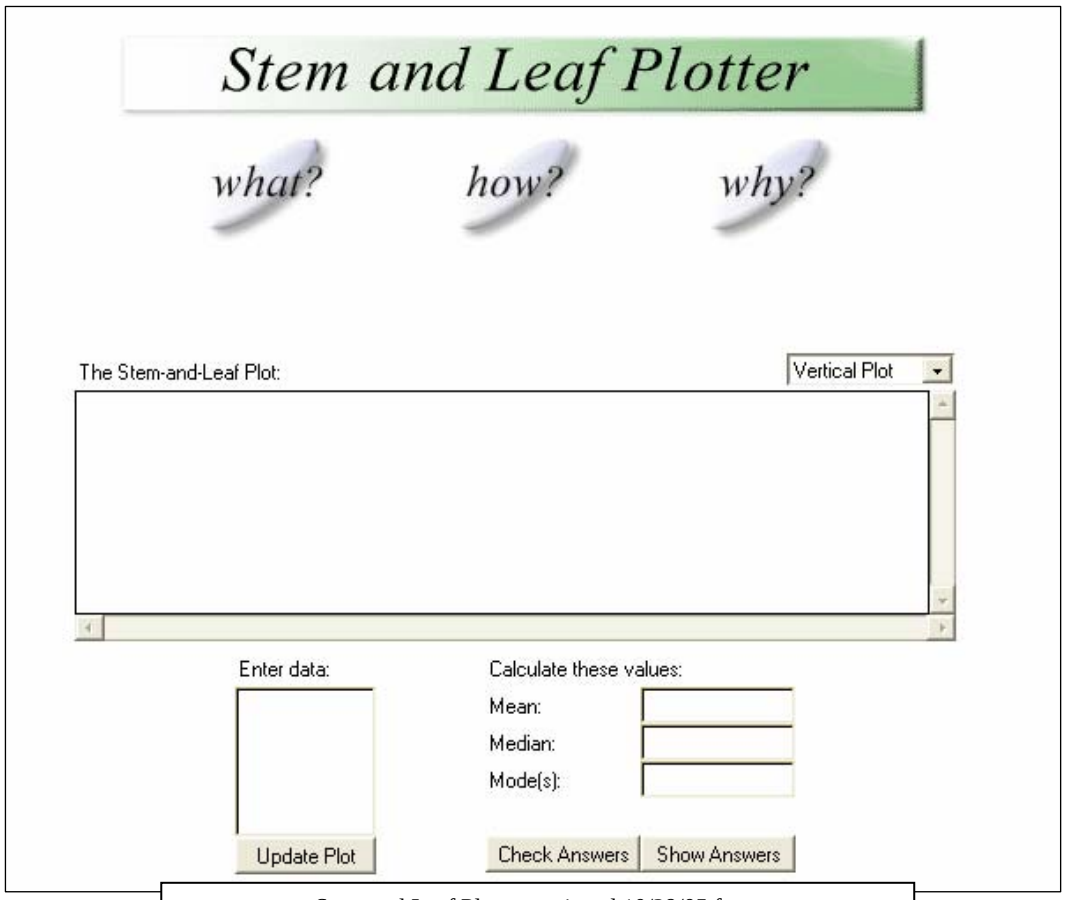
Name	Flat-footed height	Tiptoe height

Group Recording Sheet - Transparency

Name	Flat-footed height	Tiptoe height

Stem and Leaf – Computer Participant Page

1. Open the Stem and Leaf Plotter on the computer.
   http://www.shodor.org/interactivate/activities/stemleaf/index.html
2. Enter the data as the presenter calls it out in the box titled: "Enter data:" Then select "Update Plot."
3. Sketch your stem and leaf plot below.



Stem and Leaf Plotter retrieved 10/29/05 from
http://www.shodor.org/interactivate/activities/stemleaf/index.html

4. Estimate the values of the mean, median, and mode(s). Enter your estimates in the boxes. Then select "Check answers."

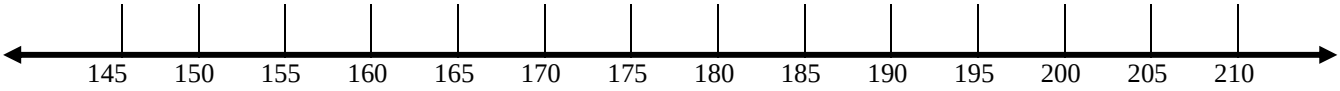
5. The stems are the values found to the left of the vertical line on the stem and leaf plot. Where do these values come from?

6. The leaves are the values found to the right of the vertical line on the stem and leaf plot. Where do these values come from?

7. If you turned the stem and leaf plot horizontally, what type of graph would it resemble? Use the drop down menu to select Horizontal Plot. Does this verify your prediction?

Box and Whisker Plot – Participant Page

I. Create a box and whisker plot that represents the flat-footed heights of the participants. Fill in the appropriate values in the table for the flat-footed heights.



		Flat-footed height	Tiptoe height
minX	**Minimum**		
Q_1	**Lower Quartile**		
Med	**Median**		
Q_3	**Upper Quartile**		
maxX	**Maximum**		
$\bar{x}$	**Mean**		
maxX-minX	**Range**		

II. Using the number line above, create a box and whisker plot that represents the tiptoe heights of the participants. Create the plot above the flat-footed plot. Then fill in the appropriate values in the table for the tiptoe heights.

Box and Whisker Plot – Computer Participant Page

1. Open the Virtual Manipulatives website. **http://nlvm.usu.edu/en/nav/vlibrary.html**
   - Click on Data Analysis and Probability Grades 6-8.
   - Click on Box Plot.
   - Click on Clear in the lower left corner to clear the list of data.
2. Using your Stem and Leaf Activity Page, enter the shortest height first.
3. Using your Stem and Leaf Activity Page, enter the tallest height second.
4. Continue by entering heights from the lower 50% of the data. Why does the "box" shift as more values are entered? _____
5. Predict what will happen to the graph as the remainders of the class heights are entered.

   _____
6. Verify your prediction by entering the upper 50% of the data. More cells will automatically be created as you need them. Was your prediction correct? _____
7. What is the minimum value of data? _____ Where do you see this on the graph?

   _____
8. What is the maximum value of data? _____Where do you see this on the graph?

   _____
9. About 75% of the class is taller than what height? _____
10. About 50% of the class is shorter than what height? _____
11. What is the median height? _____Where do you see this on the graph? _____

    _____

Box and Whisker Plot – Computer Participant Page

Experiment with the data on the computer to answer the following questions. Record your solutions below.

12. Add some data that will change the minimum value. What data did you add? Why did this data change the minimum value?

13. Add some data that will change the maximum value. What data did you add? Why did this data change the maximum value?

14. Add some data that will shift the median to the left. What data did you add? Why did this data shift the median to the left?

15. Add some data that will shift the median to the right. What data did you add? Why did this data shift the median to the right?

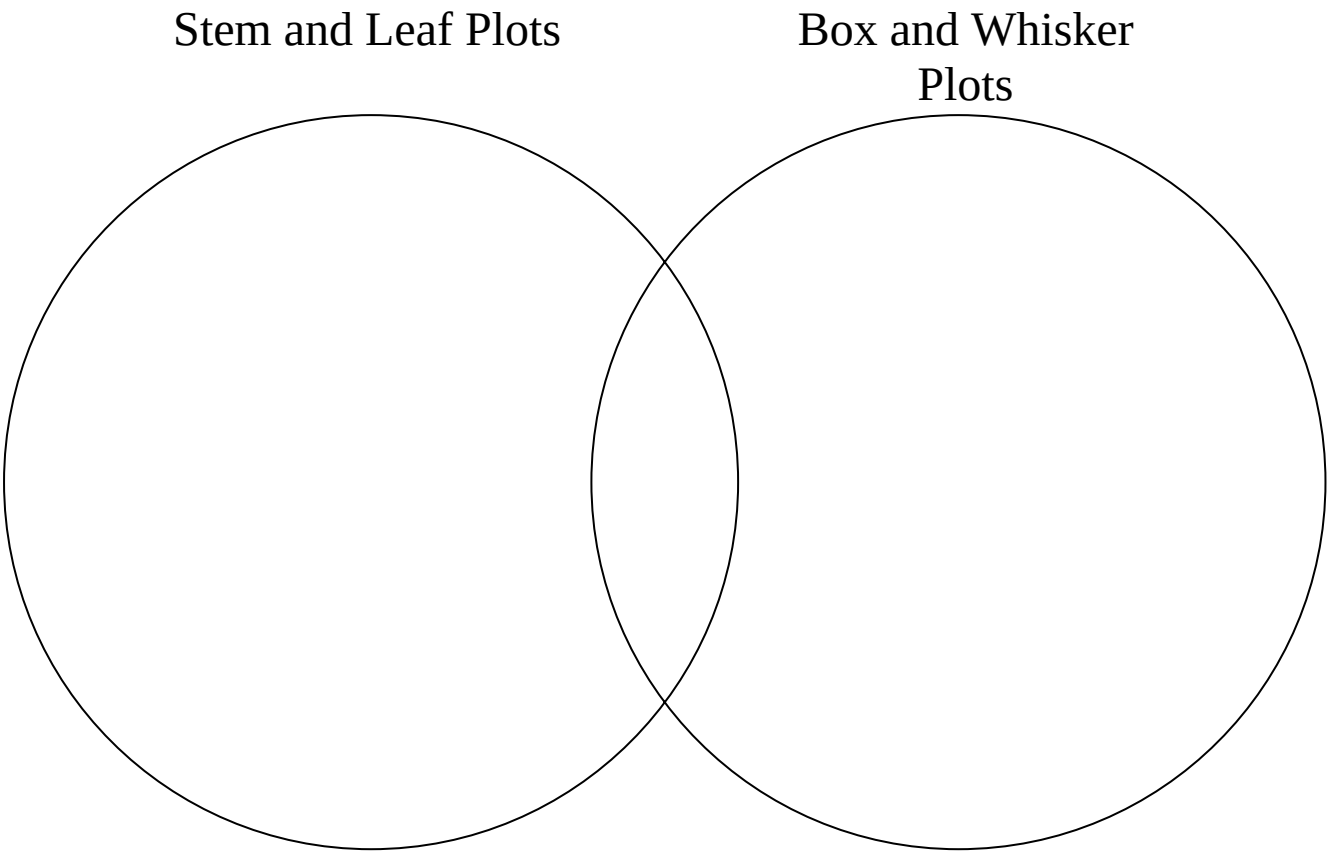
16. Add some data that will cause the whiskers to be equal in length. What data did you add? Why did this data create whiskers of equal length?

17. Add some data that will cause the box sections to be equal in length. What data did you add? Why did this data create box sections of equal length?

18. Add some data that will cause the right whisker to be about twice the length of the left whisker. What data did you add? Why did this happen?

19. Generate a list of new data that will allow the average to fall in the whiskers. Why did the average fall in the whiskers?

Venn Diagram – Participant Page



Explore/Explain 1 - Intentional Use of Data

TEKS	Math		
	Tech Apps		
Question(s) to Pose to Students	Math		
	Tech Apps		
Cognitive Rigor		Knowledge	
		Understanding	
		Application	
		Analysis	
		Evaluation	
		Creation	
Data Source(s)		Real-Time	
		Archival	
		Categorical	
		Numerical	
Setting		Computer Lab	
		Mini-Lab	
		One Computer	
		Graphing Calculator	
		Measurement Based Data	
Bridge to the Classroom			