

ACTIVITY
4

Measure Up

Math Objectives:

- Graph and interpret box plots
- Graph and interpret histograms
- Generate a five-number summary of single variable data
- Analyze and interpret data and graphs

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Firm piece of cardboard/wood (refer to picture)

OVERVIEW

What is the average height of the students in your class? How does your height compare? How does your teacher's height compare? You can use statistics to answer these questions and describe the general characteristics of a set of measurements.

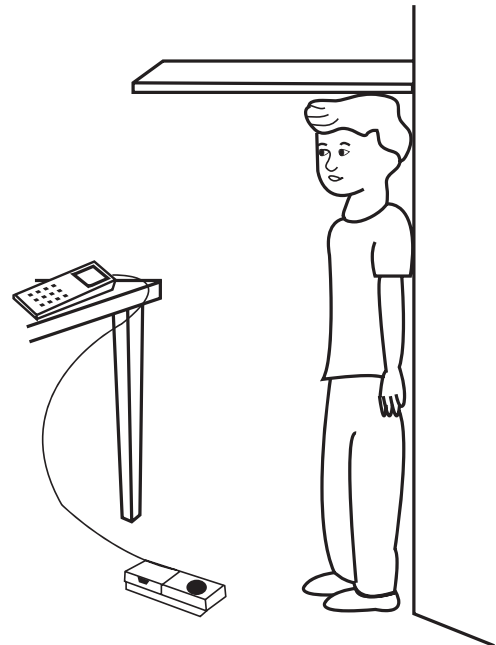
In this activity you will:

- Collect data of the heights of 12 students and the teacher in your class.
- Create a plot showing the heights of 12 students and the teacher in your class.
- Calculate the extreme values and median for the height data.
- Construct a box-and-whisker plot to summarize the height statistics.



SETUP

1. Set up the activity as shown in the picture. The CBR 2 should be positioned directly under the end of the board. The board should be long enough so that the CBR 2 can take a reading of the height of the board without the student blocking the path between the CBR 2 and the board.
2. Link the CBR 2 motion detector directly to the TI-84 Plus. You can use either the black link (I/O Unit-to-Unit) cable or the mini-USB cable.
3. The EasyData App will launch automatically if you use the mini-USB cable. If you are using the I/O cable or an older CBR, you will need to manually launch the App. To do this, press the **[APPS]** key, scroll down until the EasyData App is selected, and then press **[ENTER]**.
4. Measure the height of the teacher and the heights of 12 students. Take turns getting measured by using the board and the CBR 2. While one student is being measured, another student needs to hold the piece of cardboard or wood so that it is flat against the first student's head and level to the floor. A third student needs to run the calculator and CBR 2. They will take readings using the **Events with Entry** feature. The student holding the board must also be careful to stand out of the path of the CBR 2. Be sure to include the teacher's height because it might make a long whisker and a good topic for discussion.





DATA COLLECTION

1. When the EasyData App launches, you will see a title screen for a few seconds and then you will be taken to the home screen of the App. Notice the choices along the bottom of the screen: **File**, **Setup**, **Start**, **Graph**, and **Quit**. These are called “soft keys” and are accessed by pressing the top row of keys on the calculator, e.g., the $\boxed{Y=}$ key corresponds to the **File** soft key, the $\boxed{\text{WINDOW}}$ key will access the **Setup** soft key. See Figure 1.

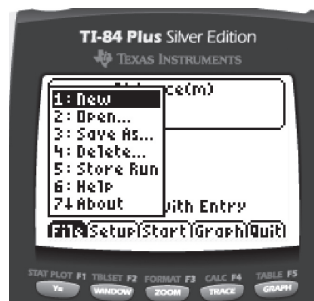


Figure 1

2. Begin each lesson by choosing **New** from the **File** menu. This will reset the App and clear out any old data. The default **Mode: Time Graph** will be displayed near the bottom of the screen. The CBR 2 will click as it begins to measure the distance to the nearest object in its path. Notice the reading at the top of the screen. See Figure 2.

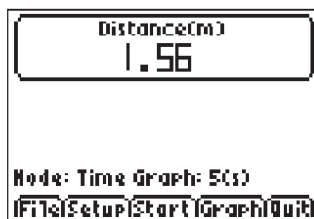


Figure 2

3. The default unit of measurement for the CBR 2 is meters. This activity works better in feet since students are more familiar with their height in feet and inches. To change the units of measurement, select the **Setup** menu by pressing the $\boxed{\text{WINDOW}}$ key on the top row of the calculator. From the **Setup** menu, choose **1:Dist** by pressing $\boxed{1}$ or $\boxed{\text{ENTER}}$ since 1 is highlighted. See Figure 3.

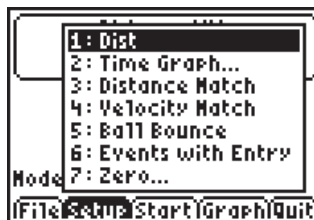


Figure 3

4. Press the $\boxed{\text{WINDOW}}$ key to access the **Units** menu. Select **2:(ft)** by pressing $\boxed{2}$ or by scrolling down until the 2 is highlighted and pressing $\boxed{\text{ENTER}}$. Then select **OK**. See Figure 4.

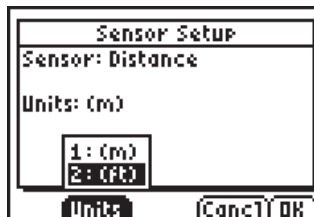


Figure 4

5. You will be returned to the main screen of the EasyData App. Select the **Setup** menu again, and then select **6: Events with Entry**. This will allow you to control when data is recorded by pressing a key on the calculator. See Figure 5.

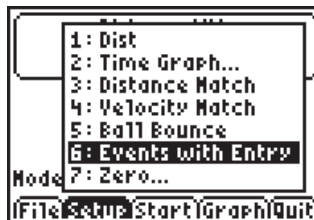


Figure 5

6. Select **Start** (by pressing the $\boxed{\text{ZOOM}}$ key) to begin collecting data.

7. You will be taken to a screen that displays the distance being recorded by the CBR 2 in real time at the top of the screen. Have the first student stand below the board as shown in the picture. To record the distance for the first student’s height, select **Keep**. See Figure 6.

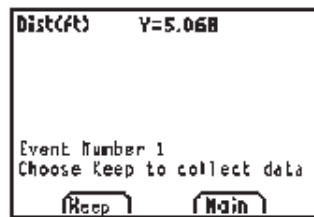


Figure 6

8. The next screen shown allows you to match a value with the distance you just recorded. Since this is the first person, type **1** and then select **OK**.

See Figure 7.

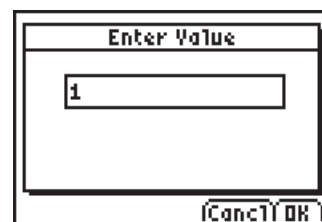


Figure 7

9. Repeat steps 7 and 8 until you have collected the heights of all 12 students and the teacher. When the **Enter Value** screen appears, increase the value each time to represent which person's height you are recording. With each recorded value, a new data point will be displayed on the graph. When finished, select **Stop**. See Figure 8.



Figure 8

10. The graph of all the data points will be displayed. You can use the right and left arrow keys to view the coordinates of the points. See Figure 9. Before continuing, take a minute for students to *sketch* this graph on their worksheet.

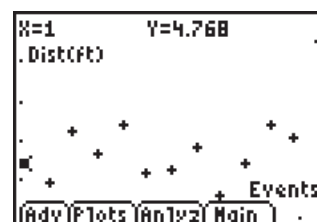


Figure 9

11. To confirm a description of the plots, select **Plots**. You will see that the plots are **Distance vs. Events**. See Figure 10. This is a good place to review vocabulary associated with this type of activity. Make sure the students understand the **Events**, although mentioned last, stand for the independent variable and the **Distance** represents the dependent variable.



Figure 10

12. Select **Main** and then **Quit** on the next screen. The screen on the right will be displayed. It will confirm the lists where your data is stored. Select **OK** to exit the App. See Figure 11.

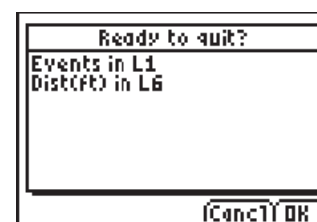


Figure 11

13. The data values you recorded, as stated in the exit screen, are in lists **L1** and **L6**. Press 2nd Y= to access the [STAT PLOT] menu and to see **Plot 1** is still turned on with the window set to display all the points collected. See Figure 12.

14. Each student needs to have this data in his/her own calculator for the Data Analysis. This is an opportunity to have the students link the data from the calculator that collected it to the rest of the class. If linking gets to be standard operating procedure, thirty students can link in less than three minutes. When one calculator links to one other, then two link to four, four to eight, eight to sixteen, etc., it goes very quickly. This leads to the entire class staying on task until everyone is ready.

★ **NOTE** For help linking calculators, see Appendix J.

15. Ask each student to save all the data in **L6**.

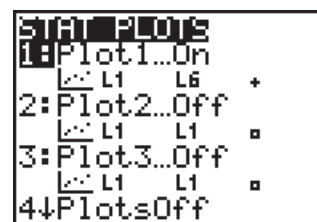


Figure 12



DATA ANALYSIS

- Sort **L6** to make analyzing the data easier. Press **[STAT]** and choose **2:SortA(** to sort in ascending order. As with any menu, you can press the down arrow until **2:SortA(** is highlighted and then press **[ENTER]**, or you can just press **[2]**. See **Figure 13**.

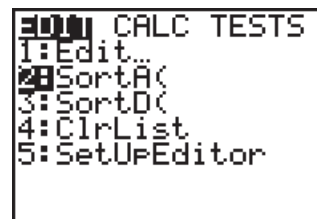


Figure 13

- You will be returned to the home screen. Press **[2nd] [6]** to enter **L6**. Press **[)]** to close the parenthesis and then press **[ENTER]** to execute the command. See **Figure 14**.

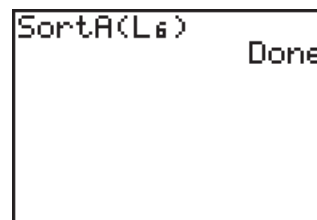


Figure 14

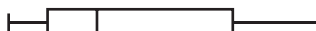
- To confirm the list has been sorted, press **[STAT] [ENTER]** and scroll right until you can see **L6**. See **Figure 15**.

L4	L5	L6	6
-----	-----	4.4799	
		4.6031	
		4.6796	
		4.7045	
		4.7612	
		4.7676	
		4.8379	
L6(1)=4.479860858...			

Figure 15

- Make sure the students understand that the order of the numbers in **L1** is not important. Have them fill in the chart on their worksheet. Adjust your explanation of boxplots to fit your students' experience with them.

BOXPLOT EXPLANATION



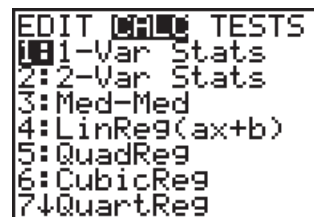
A box-and-whisker plot, also called a boxplot, is a data representation that divides a data set into four regions with equal numbers of data points. The boxplot allows you to focus your attention on a few important features without the clutter that results when all data values are displayed. The median, or second quartile, separates the set into two halves. The first quartile is the median of the lower half and the third quartile is the median of the upper half. If you have an even number of data points, the median is found by calculating the average (mean) value of the two data points in the middle. One half of the data falls between the first and third quartiles.

The 1st quartile (Q1) value tells you that 25% of the values (in this case, the heights) are equal to or lower than Q1. The 3rd quartile (Q3) value is the point where 75% of the values are equal to or lower than Q3. This means that 50% of the class data is between Q1 and Q3. A shorter box means that the data is clustered and a longer box means that the data is more spread out. When the median line is in the center of the box, the data in the middle is symmetrically distributed.

The whiskers also give you information about how the data is distributed. If you have one whisker significantly longer than the other, the data is skewed in the direction of the longer whisker. This means the data is clustered near the shorter whisker.

- Have your students follow the directions on their worksheet to sort the data in **L6** and then create their own box-and-whisker plot. Help them line up the data on the number line provided and identify the median by "counting in from both ends."

6. Repeat the idea of counting in from the ends for both the lower half and upper half of the data. Because you have 13 pieces of data, the median will be the 7th number in from either end. There will be six pieces of data in both the upper and lower halves. The median of each will be the average of the two middle pieces of data, the 3rd and 4th piece of data for each section. Guide the students in completing the plot in the space provided on their worksheet. Your students' level of experience with box-and-whisker plots should determine how much guidance you provide.
7. After their boxplot is drawn, have them use the one-variable stat feature on the calculator to see if the calculator's answers agree with the answers they have on the worksheet. Press **[STAT]**, scroll right to the **CALC** menu, and then select **1:1-Var Stats**. See Figure 16.

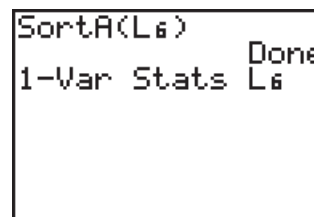


```

EDIT  [CALC]  TESTS
1:1-Var Stats
2:2-Var Stats
3:Med-Med
4:LinReg(ax+b)
5:QuadReg
6:CubicReg
7↓QuartReg
  
```

Figure 16

8. Press **[2nd]** **[6]** to enter **L6** in the home screen. Press **[ENTER]** to execute the command. See Figure 17.

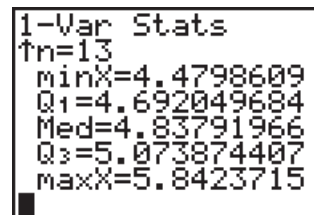


```

SortA(L6)           Done
1-Var Stats L6
  
```

Figure 17

9. Have students scroll through the screen to see if the calculator agrees with the answers they entered into the chart. Instruct them to use the down arrow key to view all the lines of the statistics screen. Have them fill in their chart with these numbers and compare them to the numbers they found on their own. See Figure 18.



```

1-Var Stats
fn=13
minX=4.4798609
Q1=4.692049684
Med=4.83791966
Q3=5.073874407
maxX=5.8423715
  
```

Figure 18

10. For further comparison, show them how to have the calculator create a box-and-whisker plot. Press **[2nd]** **[Y=]** to access the **[STAT PLOT]** menu. Press **[ENTER]** to set up **Plot 1**. See Figure 19.

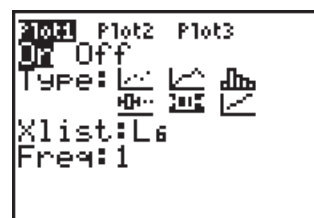


```

STAT PLOTS
1:Plot1...On
  [L1] [L6] +
2:Plot2...Off
  [L1] [L1] □
3:Plot3...Off
  [L1] [L1] □
4↓PlotsOff
  
```

Figure 19

11. If the plot is **Off**, use the arrow keys to highlight **On** and then press **[ENTER]** to select it. Use the right arrow key to scroll through the various types until **[]** is highlighted and then press **[ENTER]**. Remember the heights are in **L6**, so press **[2nd]** **[6]** to type **L6** for the **Xlist**. The **Freq**: should be set at **1** since there was one height recorded for each student. See Figure 20. Press **[ZOOM]** and choose **9:ZoomStat** to view the new graph. Have students sketch the box-and-whisker plot in the space provided on the second page of their worksheet.



```

Plot1 Plot2 Plot3
On Off
Type: [ ] [ ] [ ]
  [ ] [ ] [ ]
Xlist:L6
Freq:1
  
```

Figure 20

12. Press **[TRACE]** and use the right and left arrow keys to scroll through the plot. Notice the data at the bottom of the screen. Have students place the screen data in the appropriate place on the plot they sketch. For easy display, have them round numbers to the nearest hundredth before recording this information on their graph. See Figures 21 a–e.

13. Lead your students in a discussion about observations based on the length of both the whiskers and the boxes. The boxplot created by the calculator should closely match the boxplot the students sketched.

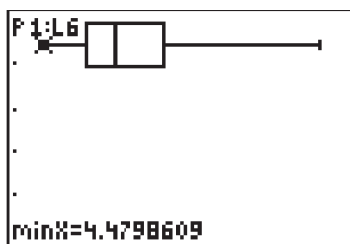


Figure 21a

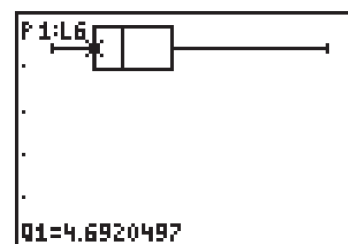


Figure 21b

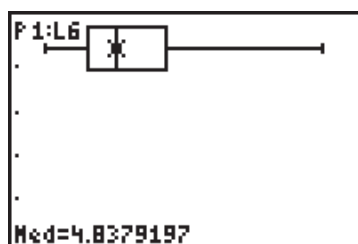


Figure 21c

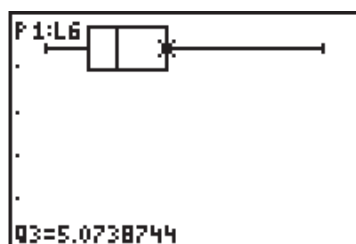


Figure 21d

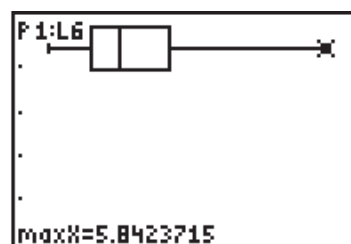


Figure 21e



EXPLORATION

1. Guide students in presenting the data in a histogram. Adjust the **Plot1** setting as shown here. Scroll until $\bar{\square}$ is highlighted and then press **ENTER**. See Figure 22. Press **ZOOM** and choose **9:ZoomStat** to view the new graph. See Figure 23.

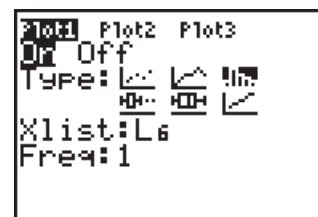


Figure 22

2. Students often have a hard time setting up a scale for a graph. They very quickly get in the habit of relying exclusively on the **9:ZoomStat** feature. Histograms often require adjustments. Press **TRACE** and scroll through the bars. Make sure they see that the **n** at the bottom of the window is the number of items in the bar marked by the cursor. See Figure 23. Encourage students to adjust the window settings to allow the graph to display the data in a more useful way. The **Xscl** determines the width of each bar starting at **Xmin**.

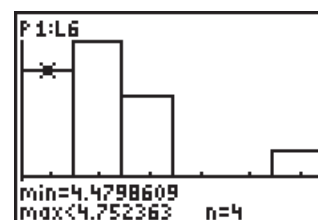


Figure 23

3. The numbers came from the CBR 2 and are very long. Round all the numbers to two decimal places for a cleaner display. Press **MODE**, position the cursor on the **2** beside **FLOAT**, and then press **ENTER**. See Figure 24.

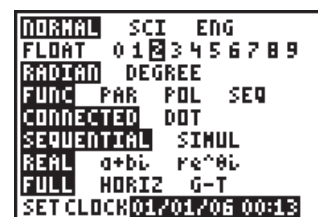


Figure 24

4. Press **WINDOW** and inspect the settings made by the calculator. This inspection can help students choose a logical selection for more appropriate settings. In the example, the current settings only show 4 bars for the histogram. Ask students to adjust the window to show more bars so that they display how many students are in smaller groupings. See Figure 25.

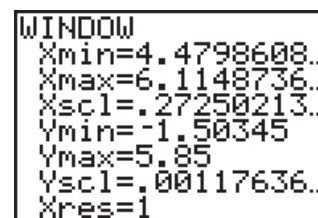


Figure 25

5. This problem will also give students an understanding of the shortcomings of the English measuring system. Units in feet and inches do not provide as many “friendly” numbers as those generated in the metric system.



EXTENSION

1. An extension to this activity is to use the list feature to turn the data into inches rather than feet. This will make it much easier to create a more useful histogram. Ask the students how many inches are in one foot. One half of a foot? $\frac{3}{4}$ of a foot? Ask how they arrived at their answers. Make sure they see it as a multiplication problem. $\frac{1}{2}$ of a foot = $\frac{1}{2} \times 12$ inches = 6 inches.
2. Lead students to how many inches are in 4.5 feet. Then move to 4.2 feet. More importantly, lead them to a formula that will convert 4.2 feet to inches. Emphasize the concept that whether feet are given as a whole number or a fraction, they should multiply by 12 to convert feet to inches.
3. Let the list features of the calculator do this computation. Press **[STAT]** **[ENTER]** and position your cursor so the name of **L5** is highlighted. This will allow you to give a command for the entire list. Type in **L6 x 12**. See Figure 26.

L4	L5	L6	5
-----	-----	4.48	
		4.60	
		4.68	
		4.70	
		4.76	
		4.77	
		4.84	
L5=L6*12			

Figure 26

4. Press **[ENTER]** and watch **L5** fill in with the desired number of inches. The measurements are all rounded to the nearest hundredth. See Figure 27.
5. Next, round to the nearest whole number. Go back to the **[MODE]** key, position the cursor on the **0** beside the word **FLOAT**, and then press **[ENTER]**.

L4	L5	L6	5
-----	53.75	4.48	
	55.24	4.60	
	56.16	4.68	
	56.45	4.70	
	57.13	4.76	
	57.21	4.77	
	58.06	4.84	
L5(1)=53.75833030...			

Figure 27

6. Press **[STAT]** **[ENTER]** to return to the Stat List Editor. Notice that all the numbers in **L5** are rounded to the nearest whole inch. See Figure 28.

L4	L5	L6	5
-----	54	4	
	55	4	
	56	4	
	56	4	
	57	4	
	57	4	
	58	4	
L5(1)=53.75833030...			

Figure 28

7. Press **[2nd]** **[Y=]** to go back to the **[STAT PLOT]** menu. Press **[ENTER]** to edit the setup of **Plot 1** and press **[2nd]** **[5]** to put **L5** in for the **Xlist**. See Figure 29. Press **[ZOOM]** and choose **9:ZoomStat** to view the new graph. The window will automatically adjust to include the data points that are now in inches.

Plot1	Plot2	Plot3
Off	Off	Off
Type: 	 	
 	 	
Xlist:L5		
Freq:1		

Figure 29

8. The histogram will look just as it had before. Press **[WINDOW]** to see the current settings.
9. Adjust the window settings and use integers. This will allow the graph to make more sense to the students. Let the **Xmin** be the first integer smaller than the current **Xmin**. To edit these numbers, position the cursor on the first digit beside the equal sign and begin typing the number you wish to enter. The current digits will be erased as you type. Press either the down arrow key or **[ENTER]** to move to the next line. See Figure 30.

WINDOW
Xmin=53.7583303
Xmax=73.378483...
Xscl=3.2700256...
Ymin=-1.50345
Ymax=5.85
Yscl=1
Xres=1

Figure 30

10. Set the **Xmax** to be the first integer greater than the current **Xmax**. Try adjusting the **Xscl** to 2 as in the example. More adjusting may be needed depending on the spread of your data. **See Figure 31.**

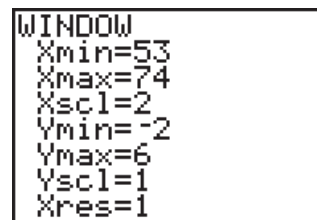


Figure 31

11. The **Ymin** is given a negative value so when you trace the histogram, the values displayed at the bottom of the screen will not be blocking the graph itself. Encourage students to see the relationship between this display and the box-and-whisker plot. A tall teacher led to a long right whisker in the boxplot and to the single box to the far right in the histogram. **See Figure 32.**

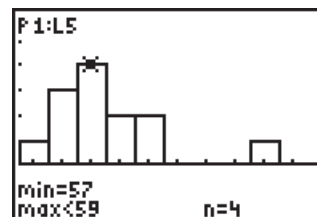


Figure 32

12. Assign the **Going Further** section for homework to check for understanding of the day's activities.

WORKSHEET ANSWERS

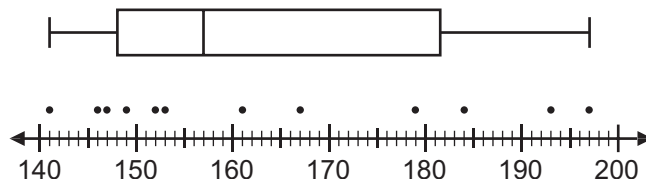
The answers to many of the questions on the worksheet will vary depending on the data collected. Answers that will not vary are provided here.

2. They should match.
5. 25%, 25%
8. It would not change. The new numbers are just different representations of the same data so the graph, which basically shows how the data is distributed, would be the same shape.

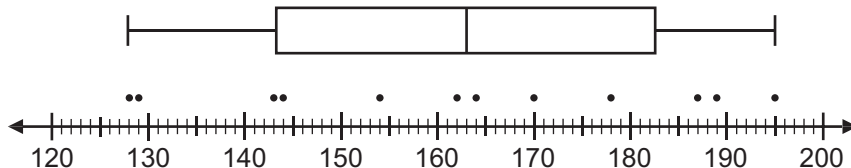
GOING FURTHER

1. No
2. The right whisker is longer.
- 3.

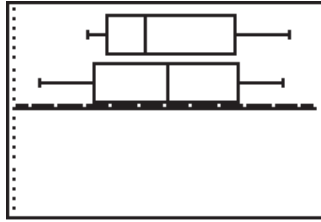
Class A



Class B

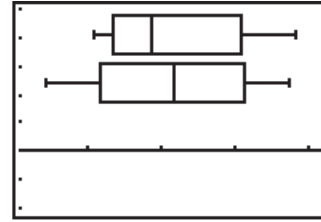


4. Pressing **ZOOM** and choosing **9:ZoomStat** may give a less than “friendly” window. Help students adjust the window settings as shown here to produce a more readable graph.



```

WINDOW
Xmin=121.1
Xmax=203.9
Xscl=20
Ymin=-2
Ymax=5
Yscl=1
Xres=1
    
```



ACTIVITY
4

Name: _____

Measure Up

Math Objectives:

- Graph and interpret box plots
- Graph and interpret histograms
- Generate a five-number summary of single variable data
- Analyze and interpret data and graphs

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Firm piece of cardboard/wood (refer to picture)

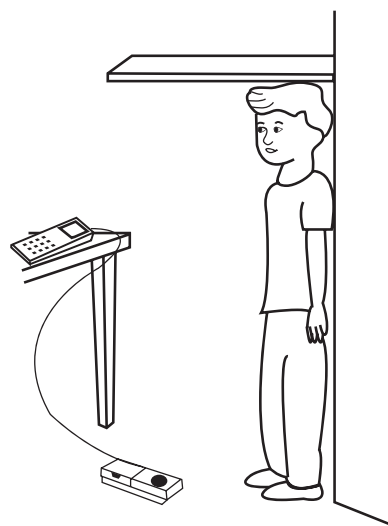
OVERVIEW

What is the average height of the students in your class? How does your height compare? How does your teacher's height compare? Use statistics to answer these questions and describe the general characteristics of a set of measurements.

In this activity you will:

- Collect data of the heights of 12 students and the teacher in your class.
- Create a plot showing the heights of 12 students and the teacher in your class.
- Calculate the extreme values and median for the height data.
- Construct a box-and-whisker plot to summarize the height statistics.

Follow your teacher's instructions to use the CBR 2 and the EasyData App to collect the heights of 12 students and your teacher. Link that data into each student's calculator in **L6**. Sort the list and fill in the chart below.



1. A special type of plot called a box-and-whisker plot shows a statistical picture of the data by graphically representing the lower extreme, lower quartile, median, upper quartile, and upper extreme. To create a box-and-whisker plot for the height data you collected, follow these steps:

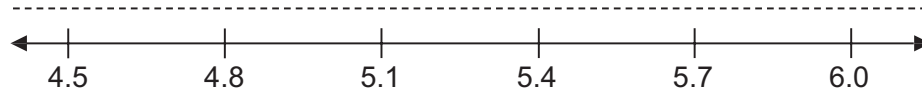
a) On the number line on the next page, use a dot to mark each of the heights you collected. Follow your teacher's instructions to find the numbers to fill in this chart.

	Your answers	TI-84's answers
minX (the minimum height)		
Q1 (the first quartile)		
Med (the median value)		
Q3 (the third quartile)		
maxX (the maximum height)		

b) On the dotted line above the number line on the next page, use dots to mark the lower extreme (shortest), and the upper extreme (tallest). The median is the middle number when all the data is arranged in order. When the number of data items is even, the median is the average of the two middle values.

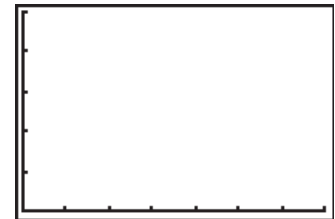
c) Draw a vertical line through the median.

- d) The lower quartile, Q1, is the median of the lower half of the data; the upper quartile, Q3, is the median of the upper half. Draw vertical lines through the lower quartile (Q1) and the upper quartile (Q3).
- e) Draw a box from the lower quartile to the upper quartile, using the vertical lines through Q1 and Q3 as sides. Draw line segments (whiskers) from the box to the extremes.



2. Press **[STAT]** and scroll over to the **CALC** menu and select **1:1-Var Stats**. On the home screen, press **[2nd] [6]** to enter **L6**. Press **[ENTER]** to execute the command. Scroll down the screen and find the numbers to fill in the second column of the chart. Did the calculator's answers agree with the answers you put in the chart at the beginning of the worksheet? _____

3. Follow your teacher's instructions to have the calculator create a box-and-whisker plot for the data and make a sketch of it here.



4. Press the **[TRACE]** key and use the right and left arrow keys to scroll through the plot, paying attention to the data at the bottom of the screen. Place the screen data in the appropriate place on your sketch. For easy display, round numbers to the nearest hundredth before recording this information on the screen.

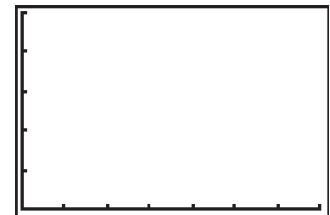
5. Approximately what percentage of the heights is greater than the upper quartile? _____ About what percentage is less than the lower quartile? _____

6. Notice that the box part of the plot represents the middle 50 percent of the data set. The size and location of the box tell you certain things about the data. A wider box indicates that the data is spread out and a smaller box means the data is clustered. Discuss the size and location of the box part of your plot. Describe how it relates to the measured heights. _____

7. The length of the whiskers on the boxplot gives a hint as to the distribution of the data. If one whisker is significantly longer than the other, the data is skewed in the direction of the longer whisker. This means that the data is bunched together near the shorter whisker. Describe the whiskers on your plot. What do the whisker lengths tell you about the heights? _____

8. If the heights in this activity were measured in centimeters rather than feet, how would your boxplot be affected? Explain your reasoning. _____

9. Follow your teacher's instructions to create a list of your data converted to inches. Create a histogram of this list and sketch it here. Use the information from the trace feature to mark each bar with the total number for that interval. Compare the information displayed in the histogram to the boxplot. What do the two have in common? Which do you prefer? Explain. _____



Going Further

Math Objectives:

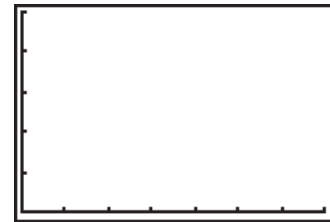
- Graph and interpret scatter and box plots
- Analyze and interpret data and graphs

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Firm piece of cardboard/wood (refer to picture)

1. The nature of a box-and-whisker plot can sometimes be distorted by data values known as *outliers*. An outlier is a value that is set apart from the rest of the data set because it is significantly lower or higher than any other number in the set. Describe how your box-and-whisker plot would be affected if the tallest person measured were replaced with a professional basketball player. Would the median, lower quartile, and upper quartile values change? _____

2. Replace the tallest person in your L5 with 7 feet to represent a tall basketball player and redraw the box-and-whisker plot here. How does it compare to the plot for the original data? _____



3. Suppose that this activity is repeated with two different classes. The average heights, in centimeters, are listed below. Arrange the numbers along the number line provided below each data set. Above the number lines, construct box-and-whisker plots for the heights in these two classes.

Class A: 193, 141, 161, 152, 179, 153, 167, 146, 184, 197, 147, 149



Class B: 195, 128, 164, 189, 162, 129, 178, 143, 154, 144, 187, 170



4. Use the built-in feature of the calculator to create a box-and-whisker plot for each class. Sketch them on the same axes here.

5. Based on these plots, write three statements comparing the heights in the two classes. _____

