



### About the Lesson

In this activity, students collect data to measure reaction time of the entire class. Using the results, students will:

- Analyze single variable data using boxplots and histograms.
- Be able to connect boxplots and histograms with the distribution of data.
- Calculate how much time they would have to react if a fast ball (travelling 150 km per hour) was pitched to them.

### Vocabulary

- boxplot
- five-number summary
- histogram
- distribution
- variability (spread)
- outlier
- Mean Absolute Deviation
- sampling

### Teacher Preparation and Notes

- This activity can be used as a performance assessment after students have studied univariate data with boxplots and histograms using TI-84 family of handhelds.
- Students will be using the Vernier EasyData® App in this activity. See the additional information in the Teaching Notes.

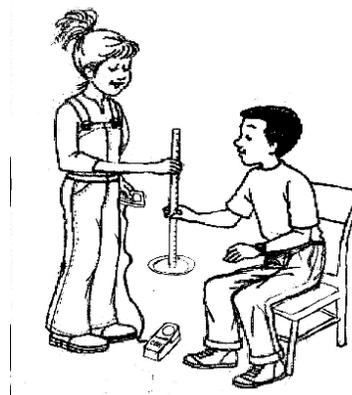
### Activity Materials

- Compatible TI Technologies:
  - TI-84 Plus\*
  - TI-84 Plus Silver Edition\*
  - TI-84 Plus C Silver Edition
  - TI-84 Plus CE

\* with the latest operating system (2.55MP) featuring MathPrint™ functionality.

- CBR 2™ motion sensor unit with mini-USB connecting cable
- Vernier EasyData® App
- Meter stick
- Paper plate or 4"x6" index card , thumb tack

### Possible Set Up:



### Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at <http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials>
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

### Lesson Files:

- Get\_On\_the\_Stick\_Student.pdf
- Get\_On\_the\_Stick\_Student.doc



### Introduction

The baseball scenario at the beginning of this activity is an attention getter and is used as an application of the Distance = Rate x Time relationship to calculate how much time a batter has to make a decision about whether to swing or not, to dodge a wild ball, or where to swing the bat. The purpose of the activity is to gather data to determine the typical reaction time of the students in your class, so that they can answer the question posed at the beginning of the activity.

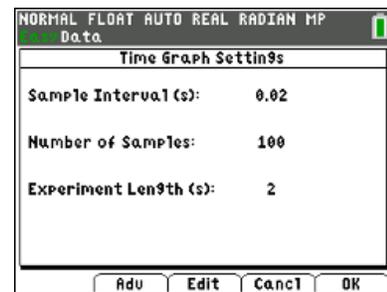
The main data analysis gives students an opportunity to make connections between a boxplot and the distribution of the data, to apply their knowledge of the relationship between the mean and the median, and how to describe the distribution of data.

**Tech Tip:** While using the EasyData® app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the key directly below it. A frequent example is shown below:

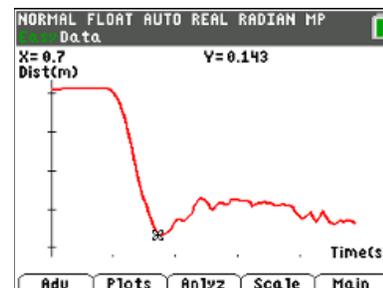
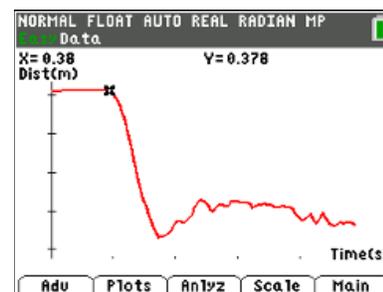


### Collecting the Data

1. The Student Activity directs students to change the default time of collection to 2 seconds. Since reaction times will be less than 1 second, this experiment length should be sufficient. If the time does not seem to be enough, edit the settings accordingly.



2. The graphs that students produce may not be level after the meter stick is caught. In the example to the right, the student did not keep the meter stick very still after he caught it, but the time of the catch is still obvious.





- Depending on the length of your class period and the size of the student groups, decide how many repetitions for each student to do.

### Looking at the Results

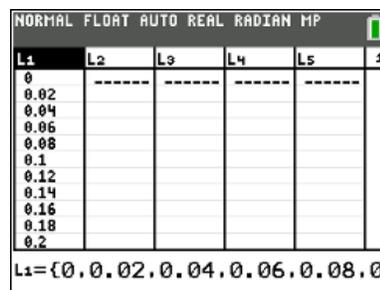
- Student data tables will vary
- Enter the five-number summary and the mean of the class data.

**Student answers will vary.**

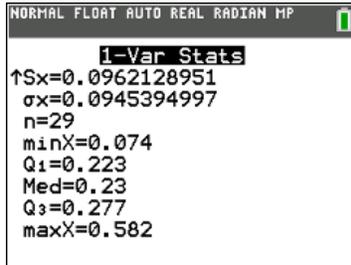
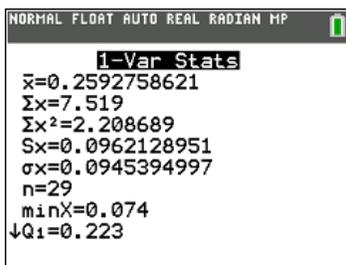
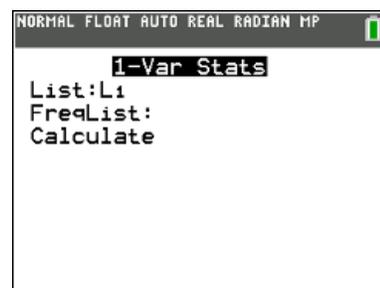
There are several options for compiling the class data:

- Designate one calculator at the front of the room for students to enter their reaction times. Then use the unit-to-unit link cables for students to link the data from the first calculator to their calculator (and then to one another) until everyone has the list in their calculator.
- If you are using TI-83/84+ calculators and have access to the TI-Navigator, you can aggregate the data electronically and send it to the students all at once.
- Have the students write their times on the board and then enter the times into L1 manually.

Before students enter the class data, they may need to clear their lists. One method is to arrow up to the Header of the list and press `clear` `enter` .



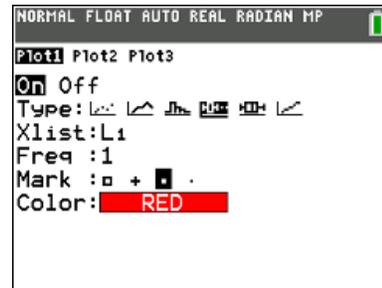
To find the mean and the five-number summary, go to the home screen, press `stat` `right arrow` to the [CALC] menu, and select 1-Var Stats. Enter the list containing the data. Since the frequency list is not being used, it can remain blank. Highlight “Calculate” and press `enter`. The mean ( $\bar{x}$ ), minX, Q1, med, Q3 and maxX are displayed when you use the arrow key to scroll through the list.



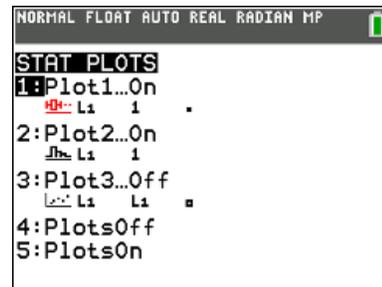
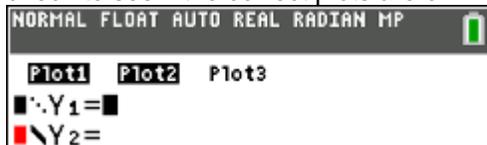
Note: The min, max, mean, and median of a list can be calculated individually if desired by pressing `2nd` `stat` and right arrow to the [MATH] menu.



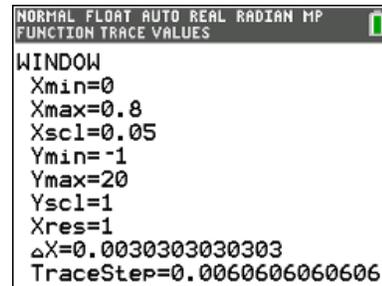
To view the boxplot and the histogram simultaneously, set up Plot1 to be a Modified BoxPlot that will indicate outliers and Plot2 to be a histogram.



The StatPlot menu should look like the screen to the right. Before going on, a good habit for your students to develop is to press  $\overline{V}$  and clear out or turn off any functions. Also check to see if the correct plots are on.

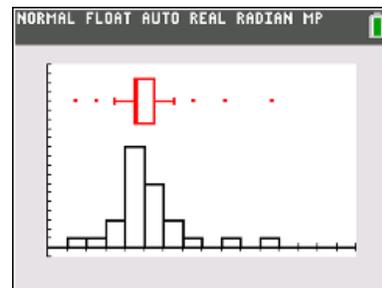


When you use  $\overline{Z}$  [ZoomStat], the two plots may overlap. In this case, increase the Ymax and adjust the Xsc1 so that the characteristics of the distribution are easily seen. The window to the right fixed the graph below.



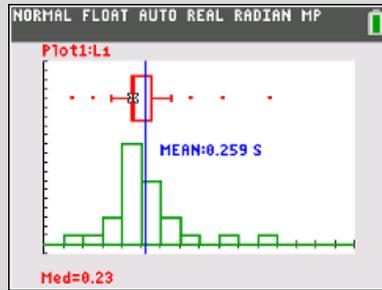
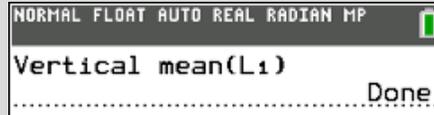
Student Sample data follows:

minX	0.074		
Q1	0.223		
Med	0.23	Mean	0.259
Q3	0.277		
maxX	0.582		





**Tech Tip:** To draw the vertical line at the mean, from the homescreen, press  $\boxed{2nd}$  [draw] and select Vertical. Press  $\boxed{2nd}$  [list] and select mean(. Complete the command as shown and press  $\boxed{enter}$  . Press  $\boxed{graph}$  to see the results.



3. Notice where the mean is relative to the median. What does this indicate about the distribution of the reaction times of your class?

**Student answers will vary.**

Sample response: The mean gets pulled to the right side of the median by high data values and to the left by low data values. When the mean is higher than the median, the distribution is skewed to the right. When the mean is lower than the median, the distribution is skewed to the left. In the sample data above, the median being on the left side of the interquartile box is another indication that the shape of the distribution is not symmetrical.

4. Calculate the IQR or InterQuartile Range ( $Q_3 - Q_1$ ). \_\_\_\_\_ Based on what you can see in the graph and the IQR, comment on the spread (variability) of the reaction times of your class.

**Student answers will vary.**

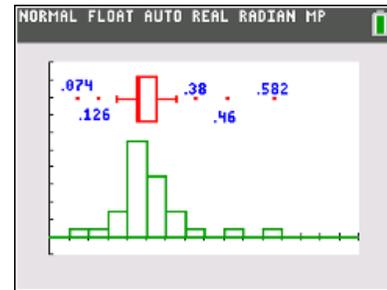
Sample response: In the sample data,  $Q_3 = 0.277$  sec. and  $Q_1 = 0.223$  sec.  $IQR = 0.054$  sec. This means that 50% of the data is within 0.054 seconds. The variability of this distribution is very small.



5. What outliers are identified in the boxplot? Explain what this means.

**Student answers will vary.**

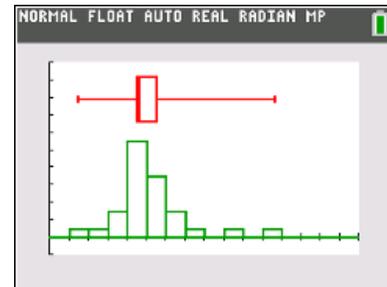
Sample response: With such a small IQR, there are five outliers (identified in the graph shown). This means that these data values are outside  $1.5(IQR)$  below  $Q_1$  or  $1.5(IQR)$  above  $Q_3$ . The researcher needs to decide if the outliers were a result of super fast students, super slow students, errors in data collection, unfair advantages, bias, or some other anomaly. Based on the reason for the results, the outliers may need to stay in the analysis or may need to be excluded.



6. If the minimum and the maximum were to be connected to the box of the boxplot, would the resulting whiskers be the same length? What do the comparative lengths of the whiskers tell you about the class data?

**Student answers will vary.**

Sample response: When the outliers are not identified on the boxplot, a whisker that is longer than the other indicates that the distribution is skewed. When the right whisker is longer, the distribution is skewed right.





7. Enter the reaction times of the girls in the class into L2 and the reaction times of the boys into L3. Setup Plot1 as a boxplot for the girls data and Plot 2 as a boxplot for the boys data. Comment on how the reaction time of the girls compares with those of the boys. Include mean, median, spread, shape, and outliers in your response.

**Student answers will vary.**

Sample Response: The mean for the girls is essentially the same as the mean for the boys (0.258 and 0.261). But the median time for the girls is slower than the boys (0.268 > 0.228). The outliers for the boys indicates that the reaction times for the boys is much more varied for the boys than for the girls (Range boys = 0.508, Range girls = 0.152). The distribution of the boys times is skewed right (Right whisker longer) whereas the distribution of the girls times is approximately symmetrical. So if you need consistency, have a girl drive the car. But if you need the possibility of a fast reaction, have a boy drive the car.

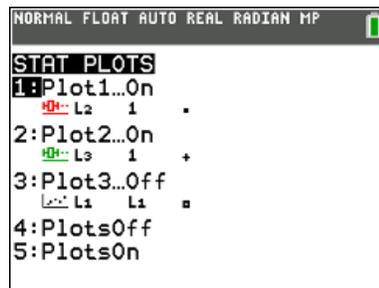
*The parallel boxplots are shown below in the question 8 response for the sample data.*

8. As support for your previous response, sketch the boxplots and provide the mean and the five-number summaries of each group

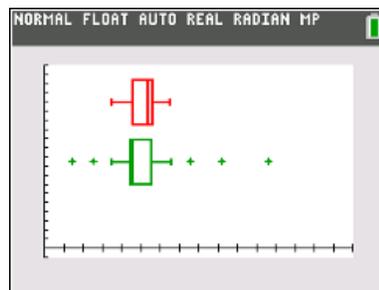
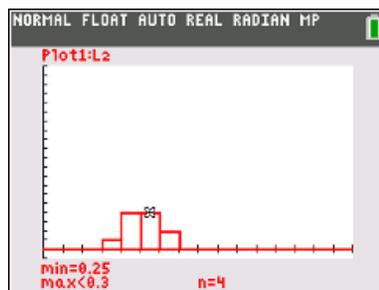
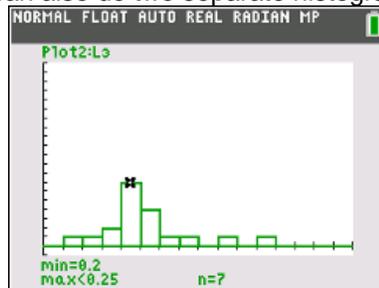
**Student answers will vary.**

Sample data:

	Girls	Boys
Min	.172	.074
Q1	.226	.22
Med	.268	.228
Q3	.278	.276
Max	.324	.582
Mean	.258	.261



To make parallel boxplots, setup Plot1 and Plot2 as shown. If desired, you can also do two separate histograms.





9. Going back to the baseball game scenario in the Introduction...with the pitch coming at you at 150 km per hour. If the ball is released 18.3 meters from home plate, how much time do you have to make your decision about what to do?

Sample Response: You have about 0.4 seconds to make your decision. If a ball is coming at you at 115 km per hour, you have about 0.57 seconds to make your decision.

### Going Further

1. More on variability: Your analysis above included looking at the IQR. Calculate the Mean Absolute Deviation (MAD) of the class data. What does it tell you about the reaction times of your classmates?

**Student answers will vary.**

Use the lists to calculate the MAD. With the class data in L1, highlight the header of L2 and enter the equation shown. Absolute value is accessed by pressing  $\boxed{\text{math}}$  and right arrow to the [NUM] Number menu. Select abs( and complete the formula as shown. Press  $\boxed{\text{enter}}$ .

**Tech Tip:** A TI-83 or a TI-84 calculator not updated to Operating System 2.55MP will display  $\text{abs}(L1-\text{mean}(L1))$  instead of  $|L1-\text{mean}(L1)|$  as shown.

The absolute value of the deviations of the data will be in L2.

L1	L2	L3	L4	L5	2
0.074	-----	-----	-----	-----	
0.126					
0.172					
0.172					
0.174					
0.22					
0.222					
0.224					
0.224					
0.226					
0.226					

L2= |L1-mean(L1)|

L1	L2	L3	L4	L5	2
0.074	0.1853	-----	-----	-----	
0.126	0.1333				
0.172	0.0873				
0.172	0.0873				
0.174	0.0853				
0.22	0.0393				
0.222	0.0373				
0.224	0.0353				
0.224	0.0353				
0.226	0.0333				
0.226	0.0333				

L2(1)=0.18527586206897

Go to the homescreen ( $\boxed{2nd}$  [quit]) and press  $\boxed{2nd}$ [list]. Right arrow to the MATH menu and select mean(. MAD = 0.064 seconds. Thus the typical difference between a data value and the mean is 0.064 seconds. The IQR = 0.054 seconds. Both measures of spread (variability) indicate the small variability in the sample class data of reaction times.

NORMAL FLOAT AUTO REAL RADIAN MP					
mean(L2)					
					0.064097503



2. What factors can change a person's reaction time? List at least three.

**Student answers will vary.**

Sample Response: Possible factors affecting reaction time from California Training Institute: Complexity of the reaction, number of choices as stimuli, type of stimulus, intensity of stimulus, gender (males faster than females), practice, fatigue, left or right hand, distraction, alcohol, receiving a warning, exercise, personality type (extroverts faster), punishment, stimulant drugs, intelligence, illness.

3. Pick one of the above factors and describe specifically how you would collect data to study the effect of that factor on reaction time—especially how you would pick participants in your study and what procedure you would follow to gather the data.

**Student answers will vary.**

4. Just a small amount of alcohol in your bloodstream can slow your reaction time by about 30%. If you are driving a car at 50 miles per hour, approximately what distance is added to your ability to stop?

Sample Response:

$$\text{Distance} = \text{Rate} \times \text{Time} = \frac{50 \frac{\text{mi}}{\text{hr}} \times (0.3 \times 0.259 \text{ s})}{\frac{3600 \text{ s}}{\text{hr}}} = 0.00108 \text{ mi} \times 5280 \frac{\text{ft}}{\text{mi}} = 5.7 \text{ ft}$$

Almost 6 feet can be the difference between crashing into another vehicle or not.