Muddy Footprints

Time:
1 class period

Suggested grade level: 8

Math Objectives:
Create a scatter plot, Find the linear regression equation for a set of data,
and use it to make a prediction, Apply the correlation coefficient *r* to data (optional)

Science Objectives:
Use a variety of tools and methods to conduct a scientific inquiry, Collect, record, and
analyze information using tools including meter sticks and rulers

Materials:
TI-73 Explorer™, Metric tape measures or meter sticks, Chalk or tape,
Straight walkway at least 10 m long

OVERVIEW

Three mountain bikers biked on muddy trails, had tons of fun, and
then came home and walked through a clean kitchen. But one
biker did not wipe their feet first. This is where the fun stopped, as
the owner of the home screamed upon seeing the mess.
Each biker denied wrongdoing. The footprints are smeared, so
their exact size can not be determined. The soles of the shoes
have no pattern. It is difficult to match the footprints to any
particular pair of shoes. But the owner of the home is determined
to find out who did it, and started an investigation by getting each biker's height:
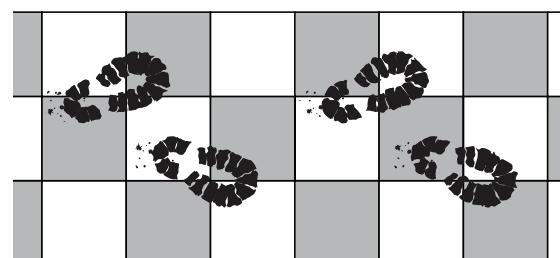Penny: 5'3"
Rex: 5'8"
Doug: 6'1"
In this adventure, students will analyze the relationship between height and stride length, and
then use that information to identify the biker who did not wipe their feet.

SET UP

1. Set up two stations with two people at each
   station. They will collect and record data
   obtained from the rest of the class.
2. At Station 1, each student's height will be
   measured and recorded. The workers at
   this station will need a meter tape measure
   or a meterstick.

3. At Station 2, the average stride of each student will be measured. The workers at this station will need a meter tape measure or a meterstick and either chalk or tape.

NOTE: An optional set up is to break the class up into groups of three or four and have each group make both measurements.

NOTE: Make a transparency of the record table to be used as a master record. Students can record their individual data on the transparency, and then they can all copy the compiled data onto their worksheets.

DATA COLLECTION

1. At Station 1, use the tape measure or meterstick to measure each student's height without shoes to the nearest half centimeter, and record it next to their name in the record table.
2. At Station 2, mark a starting line with chalk or tape. Have each student stand with the backs of his or her heels at the edge of the starting line. Starting at this point, they should take 10 normal-length walking steps in a straight line. After the 10th step, the student should stop and bring his or her heels together. Mark the final position of the back of the student's heels and measure the distance in centimeters between that mark and the edge of the starting line. Calculate the average stride length by dividing this distance by 10. Record each student's average stride length in centimeters in the record table.
3. Compile all data for all individuals on a master record.

DATA ANALYSIS

1. To build a list in the calculator, begin by pressing [LIST] . If a list contains any old data, clear it by first highlighting the list number, and then press [CLEAR] [ENTER] . **See Figure 1.**

Figure 1

2. In L1, type in each person's height. In L2, type in each person's average stride length. Make sure that both pieces of data for a particular student are in the same row. Do not enter the student's names in the data lists in your calculator. **See Figure 2.**
3. Press [2nd] [PLOT] to begin analyzing the data.
4. Press [1] or [ENTER] to access **PLOT1.** Turn the plot ON and choose a scatter plot. If L1 and L2 are not listed for XList and YList as shown, move down to each, press [2nd] [STAT] and select **1:L$_1$** or **2:L$_2$**. **See Figure 3.**

Figure 2

5. Press [GRAPH] . Then, press [ZOOM] and select **7:ZoomStat.** **See Figures 4a - b.** This scatter plot shows a graph of some sample data. Do not expect your data to look exactly like this.

NOTE You may prefer to have students select an appropriate viewing window instead of using **7:ZoomStat.**

Figure 3

6. Next, you will use the calculator to determine the equation for the straight line that fits your data the best. You can use your equation to predict the stride length of any person, based on their height.
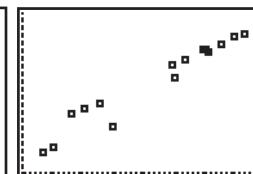

Figure 4a   **Figure 4b**

7. There is a specific mathematical process that can be used to determine the equation of a straight line that best fits a group of data points. It is called linear regression. It makes sense to use linear regression when the pattern of data points is roughly linear. If the pattern of data points has some other appearance, then a different kind of regression process might be more appropriate. Our pattern appears to be linear, so linear regression makes sense for this application. When we use linear regression, we will get an equation of the form: stride length = (a)(height) + b where a and b are constants.

🍎 **NOTE** You can complete the adventure without discussing the correlation coefficient. If you wish to do so, you can skip step 8.

8. Turn on the calculator's **Diagnostic** function by pressing [2nd][CATALOG]. Scroll down to **DiagnosticOn**. Press [ENTER] twice. **See Figures 5a-b.**

Figure 5a

Figure 5b

9. Use the LinReg function to perform the linear regression and store the resulting equation in variable **Y₁.** Press [2nd] [STAT]. Use to highlight **CALC** and select **5: LinReg(ax+b). See Figure 6.**
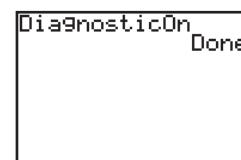
Figure 6

10. The LinReg function should be displayed on the Home screen. Press [2nd] [STAT]and select **1:L₁.** Next, press [,] [2nd] [STAT]and select **2:L₂.** Then press [,] [2nd][VARS], and select **2:Y-Vars.** Select **1: Y₁. See Figure 7.**
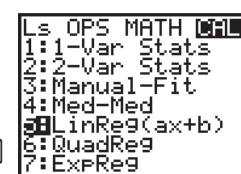
Figure 7

11. Press [ENTER] . This calculates the equation for a straight line that fits your data best. The screen will display the a and b values that make the linear equation fit the data. If you performed step 8, the r^2 and r values will be displayed. The r value tells how well the line fits the data. An r value that is close to 1 means that the line fits the data very well. **See Figure 8.**
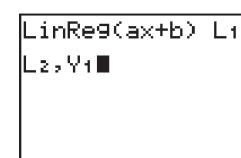
🍎 **NOTE** If you are not discussing the correlation coefficient, edit the student worksheet by deleting question 1.

12. Write the r value and the equation for your data on your worksheet. You can also see this equation by pressing [Y=] . **See Figure 9.**

Figure 8

13. Press [GRAPH] to see the line graphed on your plot. **See Figure 10.**
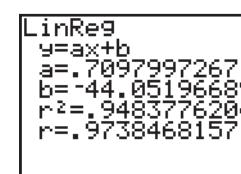14. Answer the questions on your worksheet.

✈ **EXTENSION ACTIVITY**
Determine if there is a relationship between the size of a person's shoes and his or her height.

Figure 9

DISCUSSION NOTES
This activity introduces the concepts of linear regression and r values through an analysis of the relationship between height and stride length. The variable r stands for the c*orrelation coefficient.* The correlation coefficient is a number between –1 and 1 inclusive which measures the degree to which two variables are linearly related. The r value tells you how well the linear regression equation fits the data. An r value that is close to the absolute value of 1 means that the line fits the data very well, and predictions will be very accurate. Tell students that they will learn more details about the correlation coefficient in their college math classes.

Figure 10

The worksheet guides students to make predictions by substituting values into the linear regression equation. You may also wish to show them afterwards that they could have also studied the table of x-and y-values for the equation by pressing [2nd][TABLE] on their calculator.
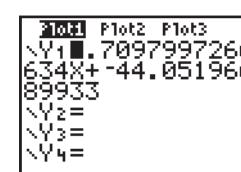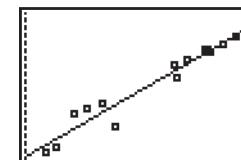
WORKSHEET ANSWERS

Data in the record table will vary.

1. Answers will vary. They should be above 0.9 if measurements were taken carefully.
2. Yes
3. Answers will vary. Sample data gives y = 0.7098x – 44.05
4. Answers will vary.
5. Possible answers: the person was taking larger or smaller steps than usual, the person's normal stride does not follow the usual trend, or the stride length was measured incorrectly.
6. Based on sample equation in question 3, $x = \frac{y + 44.05}{0.7098}$.
7. Answers will vary.
8. Based on the sample data, Penny most likely left the footprints.

   $x = \frac{y + 44.05}{0.7098} = x = \frac{64.5 + 44.05}{0.7098} \approx 152.9$

   152.9 cm is just over 60 inches, which is just over 5 ft. Penny's height is closest to 5 feet.

TI-NAVIGATOR™ EXTENSION ACTIVITY

1. Explain that the correlation coefficient measures the strength of a linear relationship between two variables. A value of 1 or –1 indicates a perfect linear relationship—the points form a straight line. Values near 1 or –1 (such as 0.9 or –0.9) indicate a stronger relationship (points are closer to forming a straight line) than values near zero (such as 0.2 or –0.2) which indicate a weaker relationship (points are farther from forming a straight line). A positive value indicates a positive relationship (as x increases, y increases); a negative value indicates a negative relationship (as x increases, y decreases).
2. Load the **corr1-4.act** activity settings file. The activity settings files can be found on the CD located in the back of the book.
3. For each graph, have students guess the r value. Collect guesses using **Quick Poll.** Discuss and correct student's thinking as needed. Accept reasonable answers.
4. Repeat with the **corr5-8.act** activity settings file.
5. Load the **anycorr.act** activity settings file. Tell students to move their cursors to form a scatter plot with a correlation coefficient of about 0.8. They will have to work as a group to achieve this. Repeat with different coefficients, both positive and negative.

Muddy Footprints Worksheet

ADVENTURE

11

Math Objectives:
Create a scatter plot, Find the linear regression equation for a set of data,
and use it to make a prediction, Apply the correlation coefficient *r* to data (optional)

Science Objectives:
Use a variety of tools and methods to conduct a scientific inquiry, Collect, record, and
analyze information using tools including meter sticks and rulers

Materials:
TI-73 Explorer™, Metric tape measures or meter sticks, Chalk or tape,
Straight walkway at least 10 m long

In this adventure, you will analyze the relationship between height and stride length, and then use that
information to identify the mountain biker who most likely tracked muddy prints onto the clean kitchen floor.

1. What is the *r* value for the straight line that best describes your data for height versus stride length?

2. Do you think that the straight line fits the data well?

3. What is the equation that describes the relationship between height and stride length?

4. Using your equation in question 3, predict the stride length of a person who is not a student in your class
   (for example, your teacher, your principal, or a student in a different class) based on his or her height.
   Then measure the person's actual stride length. How close was your prediction to the actual stride length?
   (Remember, *x* is height and *y* is stride length.)
   Prediction _____ Actual length _____ Difference _____

5. Give one possible reason that a prediction from your equation could be incorrect.

6. Solve for *x* in the equation found in question 3.

7. Using the equation in question 6, predict the heights of people with the following stride lengths.
   (Remember, *x* is height and *y* is stride length.)
   a) 75.5 cm _____
   b) 45.5 cm _____
   c) 50.0 cm _____

8. The stride lengths in the kitchen were between 64 and 65 cm long. Using your equation, which of the mountain bikers most likely left the muddy footprints on the floor? Explain. (Hint: Remember to convert the biker's heights to centimeters.)

Record Table

Student Name	Height (cm)	Stride Length (cm)