Capsule Lesson Summary

Conduct an experiment to measure students' reaction time when attempting to catch a falling ruler. Calculate the mean, median, and mode of each student's data in order to determine the student(s) with the fastest reaction time.

Materials

Teacher	• Crisp dollar bill	**Student**	• 30 cm ruler • Calculator • Worksheets P4(a), (b) and (c)

Description of Lesson

Note: In this lesson we make use of three statistical averages: mean, mode, and median. The lesson explains how to compute each of these numbers for a given set of data. The term *average* in everyday life often refers to the mean; however, in this lesson, use the specific terms *mean*, *mode*, and *median*. You may wish to discuss these distinctions with your students during the lesson.

Select a student and conduct the following experiment.

Hold the end of a crisp, new dollar bill so that it is hanging vertically. Tell the student to hold a thumb and forefinger apart on either side of the dollar bill near the center.

T: ***When I drop the bill, try to catch it by closing your thumb and forefinger. Do not move your hand down.***

Drop the bill and let the student try to catch it. Repeat the experiment with several other students. Most likely all, or nearly all, of the students will fail to catch the bill.

T: ***Why is the dollar bill so hard to catch?***

S: ***It falls too fast.***

S: ***We don't know when you will release the bill.***

T: ***Yes. It takes a certain amount of time for you to react and catch the bill. This is called* reaction time.**

Write this term on the board.

T: ***What must your brain and body do in order for you to catch the bill?***

Lead a discussion about the steps the brain and body perform:

1. The eyes see the bill start falling and send a message to the brain.
2. The brain receives that information and decides what to do.
3. The brain sends a message to the fingers telling them to close.

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T: ***Each of these steps takes time, and the total amount of time is your reaction time.***

You are going to work with a partner and drop rulers to measure your reaction time. Why do you think we will use rulers instead of dollar bills?

S: ***You don't have enough dollar bills.***

S: ***Rulers fall more smoothly than dollar bills.***

S: ***Rulers are longer than dollar bills.***

S: ***With a ruler, we can measure how far it falls.***

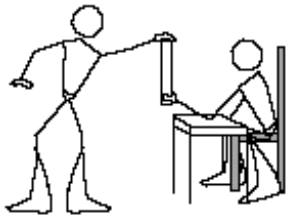
Pair students and equip each pair with a 30 cm metric ruler. Distribute Worksheet P4(a). Let students try the experiment a few times (without recording the results) before continuing.

T: ***We want to measure and compare your reaction times. In order to compare, we must all do the same thing. Who can suggest some rules for everyone to follow?***

Lead the class to establish rules similar to the following:

- The catcher's elbow must be on the table with the forearm held horizontally.
- The catcher's thumb and forefinger must be apart, away from the ruler about 2 cm on each side.
- The dropper holds the ruler with 0 at the bottom, even with the catcher's fingers.
- After a drop, measure how far the ruler drops to the nearest centimeter.
- If the catcher misses the ruler entirely and it falls to the floor, record that try as 30 cm.
- Repeat the experiment ten times and record the data on Worksheet P4(a).

Select one pair of students to demonstrate the technique three or four times at the front of the room. Draw a chart on the board to record the results, for example:



Trial	1	2	3	4	5	6	...
Drop (cm)	17	30	21	15			

The student pairs should each take a turn at being the catcher, repeating the experiment ten times. On Worksheet P4(a), a student should record only the data from his/her ten tries at being the catcher.

T: ***When you finish ten trials each, graph your own results. Connect the dots on your graph with line segments to form a line graph.***

Observe the activity to confirm that students perform the experiment correctly. As necessary, assist students who need help drawing a line graph of their data.

When most students have finished, continue the collective discussion.

T: ***We want to know who in this class has the fastest reaction time. How can we determine who is fastest?***

Encourage students to suggest several methods, for example, finding the lowest total or the lowest mean or the single smallest measurement.

Call attention to Worksheet P4(b).

T: ***Before determining who in our class has the fastest reaction time, let's look at the data on Worksheet P4(b) for four imaginary students. Each of these students thinks he or she has the fastest reaction time, but each for a different reason. Try to find the reason why each student believes he or she has the fastest reaction time.***

Let students work at least five minutes on their own or with their partners. Be sure students know that they may use calculators. While students are working, draw the table from the next illustration on the board, leaving room to draw another column on the left.

T: ***Select one of the four people and tell me why you think that person believes his or her reaction time is the fastest.***

Your students might suggest two or three of the following reasons. Explain other reasons yourself. As you consider each reason, compute the appropriate number for the four people and add one line of data to the table on the board.

S: ***Arnold might believe that he has the fastest reaction time because his drop of 5 cm is the single best measurement amongst all of the data.***

Direct students to find the single best result for each of the four students, and enter that result in the table. (See the first line in the table below.)

S: ***Lucy might believe that she has the fastest reaction time because her total of 156 cm and her mean of 15.6 cm (156 ÷ 10) are the lowest.***

Review how to compute the mean (add the ten numbers and divide by 10). Ask students to compute the mean for all four students.

Reason	Arnold	Lucy	Pierre	Michelle
Best result (cm)	(5)	7	14	11
Mean (cm)	16.9	(15.6)	16.3	16.5

S: ***Pierre might believe that he has the fastest reaction time because his most common result, 15 cm, is lower than anyone else's most common result.***

T: ***This number is called the mode. Pierre feels that he is most consistent.***

Ask students to find modes for all four students (see the third line in the following table). Note that Lucy has three modes.

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S: ***Michelle might believe that she has the fastest reaction time because she has the fastest middle result. She arranges her ten results in order (11, 12, 12, 13, 13, 16, 16, 16, 28, 28) and looks at the average of the middle two results:*** $\frac{13+16}{2}$ ***= 14.5.***

T: ***This number is her median. She has the best median of the four people.***

Ask students to compute medians for all four students. Stress that you put the ten numbers for a person in order before looking at the two middle results.

Reason	Arnold	Lucy	Pierre	Michelle
Best result (cm)	(5)	7	14	11
Mean (cm)	16.9	(15.6)	16.3	16.5
Mode (cm)	19	16 or 17 or 18	(15)	16
Median (cm)	18.5	16.5	15	(14.5)

T: ***Each person has a good reason for claiming to have the fastest reaction time. Do you understand their reasons? Who do you think has the best claim for being fastest?***

Discuss student comments and compare the four reasons.

Distribute Worksheet P4(c).

T: ***Let's use each of these four methods to determine who in this class has the fastest reaction time. To do this, use the data from your ten trials to compute these four numbers (best result, mean, mode, and median).***

After allowing time for individual students or partners to complete Worksheet P4(c), ask students for their best result and determine the best single result in the class. Also find the lowest mean, mode, and median. Record this information in a column added to the left in the table on the board. For example:

In our class		Reason
Nathan	6 cm	Best result (cm)
Carla	11.2 cm	Mean (cm)
Melinda & Ameed	14 cm	Mode (cm)
Carla	11.5 cm	Median (cm)

Let students express opinions about who they believe has the fastest reaction time. There is no one correct answer to this question; it is a matter of interpretation.

For your information, some advantages and disadvantages of using each method are listed below. Discuss some of these, especially if mentioned by students.

Method	Advantages	Disadvantages
Single Best Result	Many winners, especially in athletics (for example, the long jump or shot put), are determined by the one best effort.	Only one measurement counts for each person.
Mean	All data count equally.	One or two bad (or good) results strongly affect the mean.
Mode	To some extent, the mode reflects consistency.	The mode often reflects only two or three values and is easily changed by new data.
Median	All data affect the median, but extreme data does not affect it strongly.	Very inconsistent data may push the median one way.

Instruct students to look at the line graphs of their data.

T: ***If a person has a consistently fast reaction time, what will the line graph look like?***

S: ***The dots and lines will be near the bottom of the graph.***

T: ***What will the graph for a person with a consistently slow reaction time look like?***

S: ***The dots and lines will be near the top of the graph.***

T: ***If a person's reaction time improves during the ten trials, what will the line graph look like?***

S: ***The dots and lines will go from the upper left to the lower right.***

Note: The highly erratic results in this experiment indicate that this is not a very reliable technique for measuring reaction time. Still, this lesson is useful to illustrate reaction time, it is simple to perform, and it requires students to collect and analyze data.

Writing Activity

Suggest that students write about the line graphs for their reaction time.

Home Activity

Some students may like to use the experiment from this lesson to determine who in their family has the fastest reaction time.

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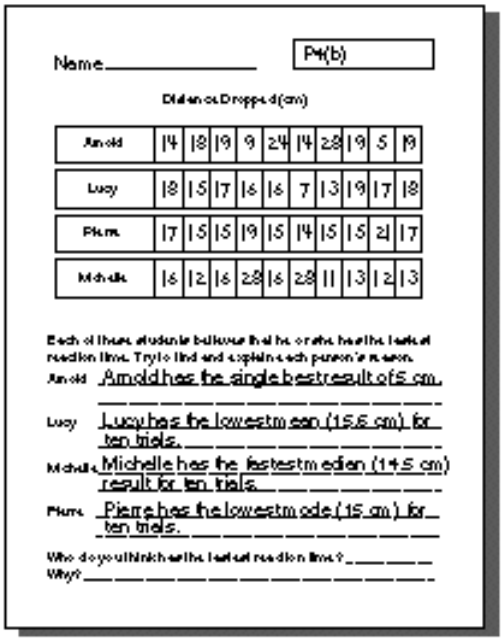

Name _____ P4(b)

Distances Dropped (cm)

Arnold	14	18	19	9	24	14	28	19	5	19
Lucy	18	15	17	16	16	7	13	19	17	18
Pierre	17	15	15	19	15	14	15	15	21	17
Michelle	16	12	16	28	16	28	11	13	12	13

Each of these students believes that he or she has the fastest reaction time. Try to find and explain each person's reason.

Arnold Arnold has the single best result of 5 cm.

Lucy Lucy has the lowest mean (15.6 cm) for ten trials.

Michelle Michelle has the fastest median (14.5 cm) result for ten trials.

Pierre Pierre has the lowest mode (15 cm) for ten trials.

Who do you think has the fastest reaction time? _____

Why? _____