

## Teacher Guide: Reaction Time 2



### Learning Objectives

Students will...

- Review basic statistics including range, mode, and median of a data set.
- Determine the mean of a data set.
- Understand the effect of outliers on the range, mode, median, and mean.
- Compare data sets from related experiments.
- Draw conclusions based on data.



### Vocabulary

mean, median, mode, outlier, range



### Lesson Overview

In the Student Exploration sheet of the *Reaction Time 1* Gizmo™, students found the range, mode, and median of a data set. The Student Exploration sheet for the *Reaction Time 2* Gizmo focuses on calculating the mean of a data set and finding the effect of outliers.

In addition to learning statistics, students will also practice the scientific method and experimental design.



The Student Exploration sheet for *Reaction Time 2* contains three activities:

- Activity A – Students learn how to calculate the mean of a data set, and use the mean to compare the results of three experiments.
- Activity B – Students see the effect of an outlier on range, mode, median, and mean.
- Activity C – Students design their own reaction-time experiment.



### Suggested Lesson Sequence

1. **Pre-Gizmo activity** (🕒 10 – 20 minutes)  
This lesson was designed as a follow-up to the *Reaction Time 1* activity. Some knowledge of range, mode, and median is assumed. Students should complete *Reaction Time 1* before attempting *Reaction Time 2*.

To introduce the idea of mean, ask students for examples of averages in sports statistics. For example, Kobe Bryant might score an average of 29.2 points per game, or Jake Peavy might give up an average of 2.68 runs per game. Ask your students if they know how these sports averages are calculated. (Note: Point out that the word “average” usually refers to the mean, but not always. “Mean” is considered more correct.)

Another way to introduce the mean is to think of just two numbers. The mean is a number halfway between those numbers. How do you calculate a number that is halfway between 23 and 91? Ask students to solve this problem and then share their strategies.

2. **Prior to using the Gizmo** (🕒 10 – 15 minutes)

*Before* students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class. At this point, letting students share how they thought about the questions is more valuable than “going over” the correct answers. After the discussion, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations.

3. **Gizmo activity** (🕒 15 – 20 minutes per activity)

Assign students to computers. Students can work individually or in small groups. Have students work part of the Student Exploration sheet using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Extending the Gizmo** (🕒 15 – 20 minutes each)

Here are some suggestions for extending the activities in the Student Exploration sheet.

Activity A Extension – Continue to explore the idea that the mean is the fairest way to compare different data sets. For example, suppose you wanted to compare two basketball players. Would it be fair to simply add up each player’s points, even if one player was injured for a while and didn’t play as many games? A better comparison would be to compare the points per game, or mean score, for each player.

Activity B Extension – Discuss why outliers have an effect on the mean and range, but do not tend to change the median or mode. Present a variety of data sets with outliers, and ask students to predict if the mean will be higher than or lower than the median. (If the outliers are high, the mean will be greater than the median. If the outliers are low, the mean will be less than the median. An outlier tends to “pull” the mean toward it, but generally leaves the median unaffected.)

Activity C Extension – Ask each student or group to prepare a report of their experiment. The first page of the report should contain a title, the experimental question, their hypothesis, and a description of the experimental procedure. The second page of the report should contain the results of the experiment. Using the camera feature of the Gizmo, students can take snapshots of their graphs and paste them into their report, along with the associated statistics. Finally, students should write their conclusions. Each student/group can present their experiment to the class.

5. **Follow-up activity: Applying statistics** (🕒 throughout the year)

After mastering the four basic statistics discussed in this activity, students will be ready to apply these concepts throughout the school year. Students can use these statistics whenever they need to describe numerical data. Data can come from many sources:

- Class surveys. (What is the mean height of students in the class? What is the median height? What is the range of heights in the class?)
- Observing the environment. (What was the mean noon temperature in April?)
- Sports. (What was the mean number of points scored by our basketball team?)
- Experiments. (What was the mean height of the plants grown with fertilizer?)
- Grades. (What was my mean test score? What do I need to get on the last test to get a mean of 90%?)



## Mathematical Background

The main goal of the lesson in the *Reaction Time 2* Student Exploration sheet is to make sense of the mean. To find the mean of a data set, first add up all the numbers. Then divide this total by the number of terms in the data set. While students may be able to master this procedure, it is unlikely that many can explain why it results in a number that summarizes the data well.

The Student Exploration sheet presents the mean in three steps. First, students compare two groups of scores with the same number of values. For example, in the catch the ruler experiment, students might get the following results:

- Catch the ruler (no sound): 12 inches, 14 inches, 13 inches, 15 inches, 11 inches
- Catch the ruler (sound, eyes open): 11 inches, 10 inches, 14 inches, 11 inches, 9 inches

A logical way to compare these sets of scores is to add up the total scores. In this case, the total for the first experiment is 65 inches, and the total for the second experiment is 55 inches. Because smaller distances on the ruler correspond to better reaction times, you can conclude that the “with sound” experiment yielded better reaction times.

However, what happens if there is a data set with a different number of values? Suppose an “eyes-closed” experiment is done for the ruler, and the following results are recorded:

- Catch the ruler (sound, eyes closed): 8 inches, 9 inches, 9 inches, 8 inches, 11 inches, 9 inches, 10 inches, 8 inches

In this case, the total score is 72 inches, which is greater than the total for either of the previous experiments. However, this is the sum of 8 scores, rather than 5 scores for the previous experiments. What is a fair way to compare these scores? One way would be to divide each total by the number of scores, so that each score is weighted equally. The mean scores show that the best reaction times were actually produced by the third experiment (eyes closed):

- Catch the ruler (no sound) mean distance:  $65 \div 5 = 13$  inches
- Catch the ruler (sound, eyes open) mean distance:  $55 \div 5 = 11$  inches
- Catch the ruler (sound, eyes closed) mean distance:  $72 \div 8 = 9$  inches

Looking back at the original data, it is also clear that, not only does the mean allow a fair comparison of the data, but it also yields a number that is near the middle of the data. In the three data sets above, the mean is equal to the median. For data sets that are symmetrical (data is evenly distributed), the mean will usually be very close to the median. When there are a number of *outliers* (very high or very low values), the data set is asymmetrical, or *skewed*. Outliers generally have a greater effect on the mean than the median. To see why, suppose the first data set listed above contained an outlier: 12, 14, 13, 15, 11, **36**. The median changes very slightly, from 13 to 13.5 inches. The mean changes more significantly, from 13 to 16.8 inches.



## Selected Web Resources

Discussion of mean, median, and mode:

<http://www.shodor.org/interactivate/discussions/meanmedianandmode/>

Mean, median, and mode: [http://education-world.com/a\\_curr/explainthat/explainthat007.shtml](http://education-world.com/a_curr/explainthat/explainthat007.shtml)

Statistics basics: <http://www.mathsisfun.com/data.html>

*Mean, Median and Mode* Gizmo: <http://www.explorelearning.com/gizmo/id?262>

*Movie Reviewer* Gizmo: <http://www.explorelearning.com/gizmo/id?1018>